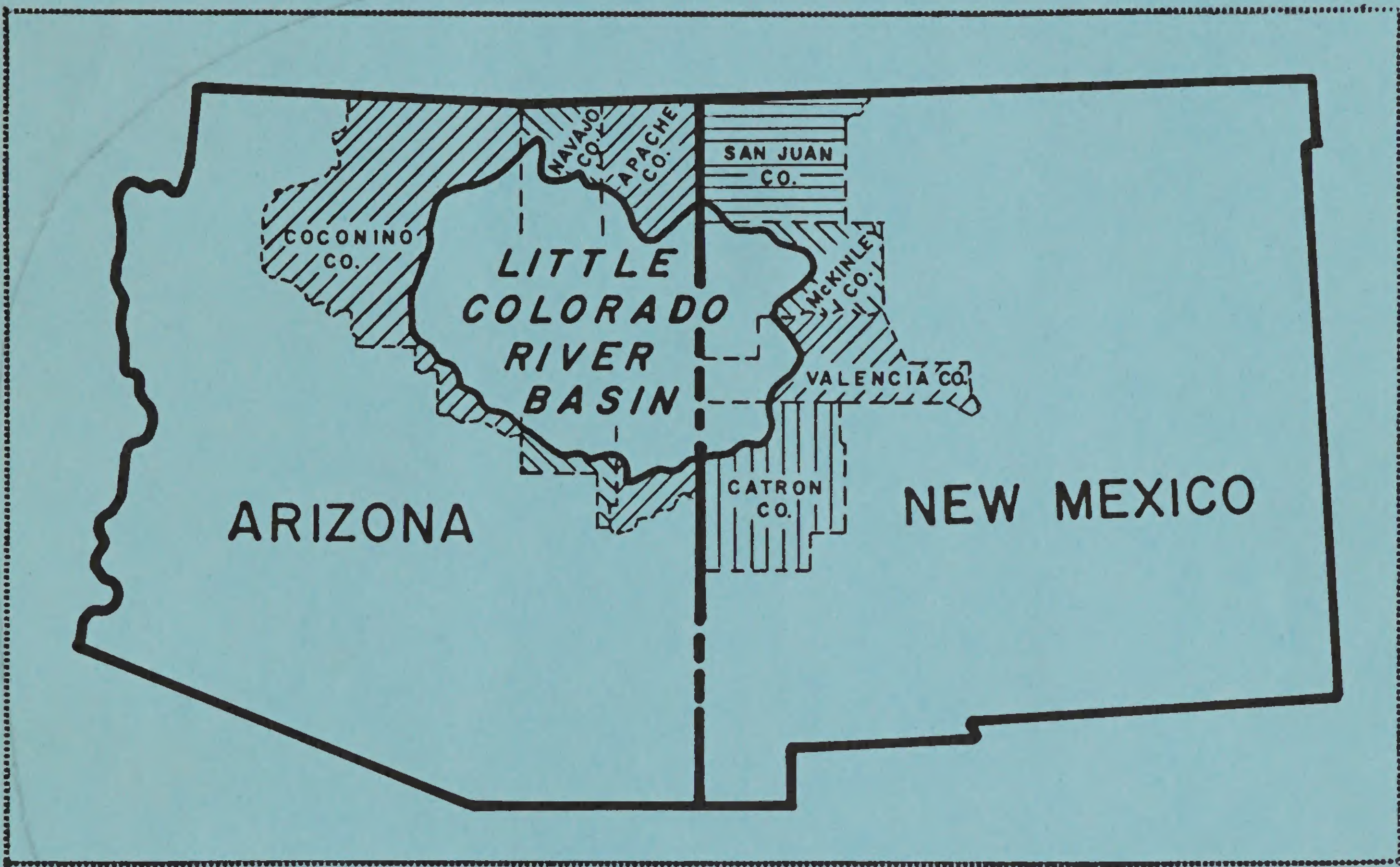
LITTLE COLORADO RIVER BASIN
ARIZONA-NEW MEXICO

SUMMARY REPORT



U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ECONOMIC RESEARCH SERVICE
FOREST SERVICE

In cooperation with the states of
ARIZONA AND NEW MEXICO

December 1981

LITTLE COLORADO RIVER BASIN
ARIZONA-NEW MEXICO

SUMMARY REPORT

PREFACE

The states of Arizona and New Mexico requested the United Stated Department of Agriculture, including the Soil Conservation Service, the Forest Service, and Economic Research Service, to participate in a cooperative river basin study of the Little Colorado River Basin. The Arizona Department of Water Resources served as the lead agency for the state of Arizona and for New Mexico it was the State Engineer's Office.

The study was completed pursuant to Section 6 of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, 68 Stat., 666, as amended and supplemented). The results of the study were initially published in 12 working papers which received limited distribution. These included: Description of Basin, Socio-Economic Base, Irrigation, Municipal and Industrial Water Supply, Rural Domestic and Livestock Water Supply, Development of Surface Water Resources, Surface Water Budgets (Including Pumped Groundwater), Erosion and Sediment, Flooding, Recreation, Fish and Wildlife, and Timber. The working papers were combined into four appendices which supplement and support the Summary Report. Titles and subsections of each appendix are given below and data from the appendices are summarized in the "Findings and Conclusions" section of this report.

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APPENDIX I: DESCRIPTION OF BASIN

- Section 1: Physical Description
- Section 2: Socio-Economic Base

APPENDIX II: WATER RESOURCES

- Section 1: Irrigation
- Section 2: Municipal and Industrial Water Supply
- Section 3: Rural Domestic and Livestock Water Supply
- Section 4: Development of Surface Water Resources
- Section 5: Surface Water Budgets (Including Pumped Groundwater)

APPENDIX III: EROSION AND SEDIMENT, AND FLOODING

- Section 1: Erosion and Sediment
- Section 2: Flooding

APPENDIX IV: RECREATION, FISH AND WILDLIFE, AND TIMBER

Section 1: Recreation
Section 2: Fish and Wildlife
Section 3: Timber

The Summary Report with its accompanying appendices present and analyze resource data that would offer solutions to problems and assist decision makers in the orderly development of water and related land resources of the Basin. The Summary Report contains a limited description of the basic resources, problems, and analyses made during the study. Although a Basin-wide comprehensive plan was not developed, alternatives were developed for selected items that appear to have a good possibility of being implemented with USDA assistance, under such authorities as Public Law 566, Resource Conservation and Development, or Public Law 46, with special cost-sharing arrangements in the Agriculture Conservation Program. These items include: irrigation, recreation, erosion and sediment, and flooding. Other study items were inventoried and resource data presented with reference to capabilities and limitations.

The results of the study can be used by county and city governments, natural resource conservation districts, planning commissions, councils of government, and other local groups in planning land use and setting priorities for allocation of resources. The U.S. Department of Agriculture can use the study results as a basis for directing its efforts in cooperation with natural resource conservation districts, soil and water conservation districts, watershed groups, and other resource development groups.

Many federal and state agencies, local organizations and groups and individuals have contributed to the study by providing council and information, and by participating in public meetings. Their cooperation and assistance is appreciated.

LITTLE COLORADO RIVER BASIN
COOPERATIVE STUDY

ERRATA SHEET

1. Effective July 1, 1981, Valencia County, New Mexico, was divided into two counties. That portion within the Little Colorado River Basin became Cibola County.

2. In June 1981, the Economics and Statistics Service was reorganized to form the Economic Research Service and the Statistical Reporting Service.

3. The Arizona Water Commission is now the Arizona Department of Water Resources.

SUMMARY REPORT

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MAPS

SUMMARY

The Little Colorado River Basin covers an area of approximately 17.2 million acres or 26,964 square miles; 21,667 square miles in northeastern Arizona and 5,297 square miles in northwestern New Mexico. The climate is characterized by mild summers and cold winters. Mean annual precipitation is between 8 and 12 inches in the valleys and plateaus, and 16 to 24 inches in the forested parts of the mountains. The topography is varied and diverse. The Basin is a scenic area of volcanic peaks, forested mountains and plateaus, rolling hills and plains, with multihued crags and cliffs cut by huge canyons. Vegetative cover consists of dense mountain forest, grasslands and nearly barren desert.

The Basin has many land and water resource problems. About 77 percent of the land is either owned or is under the control of federal or state government(s). Only 23 percent is in private ownership. The checkerboard pattern on much of the state, BLM and national forest lands has made it difficult to effectively manage these lands. The basic policy of the Forest Service has been to exchange or purchase lands that will tend to consolidate or "block-in" the national forests to make the management of these lands more effective.

One of the major land resource problems in the Basin is soil erosion. Severe erosion is occurring in some of the alluvial valleys and on the valley slopes of the Little Colorado, Puerco and Zuni Rivers. About 5,300 miles of channel bank are experiencing moderate to severe erosion. USDA presents two alternative resource improvement plans to reduce soil erosion, protect water quality and improve productivity, wildlife and esthetics. Planned elements for the two alternatives are presented in Tables 10 and 11.

Eight areas in Arizona and two areas in New Mexico were identified as having continuing flood problems. None of these areas proved to be feasible to treat under project type action using USDA authorities. In all cases, the costs of significantly reducing or eliminating the flood problems exceeded the monetary benefits.

Major recreational problems include: limited access to the areas that are suitable for recreational use, lack of awareness of recreational opportunities, overcrowding of known facilities, and vandalism.

The Forest Service, through its Road and Trail Development Program, is continually opening new areas and providing improved access to existing desirable areas. The Forest Service also has an extensive public information program that can disseminate information about recreational opportunities. However, many recreational opportunities still exist on national forests that are not generally known to the public. The Forest Service should expand its public information program.

There are five sites that have potential for water-based recreational development. These include: Woodruff Lake, Woodruff Dam (Reservoir), Ganado Lake, Red Lake, and McHood Park. All of these sites have favorable benefit cost ratios and are within the Little Colorado River Plateau

Resource Conservation and Development (RC&D) Area. The RC&D Program could provide planning and implementation assistance to each of these areas.

The intensity of wildlife management and habitat conservation practices is dependent on the objectives of the principal landowners and/or management agencies. Certain management practices may meet more than one objective. For example, water development and range seeding can benefit both cattle grazing and wildlife habitat.

Riparian zones occupy relative small areas, but are very important to wildlife. Their importance is indicated by wildlife use being disproportionately more in these areas than any other type of habitat. These sites, however, are also used by cattle; some are highly productive timber sites; and recreationalists concentrate their use in such areas. To protect these areas, livestock grazing must be managed so as to maintain adequate vegetative cover and water quality to meet wildlife requirements. In some cases this will require total livestock exclusion, in other cases deferred and/or alternate seasonal grazing would be compatible with wildlife needs. Human activities also must be managed so as to prevent or minimize the disturbance to the habitat.

There are 70 miles of streams and 6,580 surface acres of ponds, reservoirs and lakes currently suitable for fishing. Some possible opportunities for improving recreational fishing include: watershed management to minimize siltation in lakes, management of irrigation reservoirs for fish production and recreation, construction of new fishing lakes, deepening shallow lakes, eradication of trash fish and waterweed, and improve grazing and timber harvest techniques to maintain desirable vegetation cover along streamside zones.

Opportunities exist for forest lands to contribute more fully and effectively to meeting demands for wood products. Timber stand improvement (TSI) includes a variety of management practices to change stand conditions. Cost sharing programs are available to private landowners to provide tree seedlings for reforestation, windbreaks, and Christmas tree plantations. Critical management activities for the Basin involve prevention and control of wildfires and protection of forest against disease and insects. Because most of the areas desirable for wilderness, recreation and other uses are on timber lands, future timber production and utilization in some areas may be severely curtailed or halted to meet other requirements.

Water is scarce in the Basin; scarce in the sense that not everyone can use as much as he wants under the prevailing conditions. Water for irrigation is short in some years. There is very little opportunity to increase water supplies through the construction of new reservoirs because of existing water rights; however, there is a potential for improvement in the use of existing supplies by system improvements and better irrigation water management. There are three areas in Arizona (West Taylor, Springerville, and Pinetop-Woodland) that have potential for development as Resource Conservation and Development Projects Measures.

Communities of the Basin have been and will be faced with problems of water shortage. Storage and distribution systems are inadequate in some areas.

Data was obtained in 41 separate communities. Of these, 30 are in need of replacement and/or modification (expansion) of their distribution systems; 26 need additional water storage for fire protection; and 22 need their water supplies augmented.

Rural domestic and livestock water supplies are also inadequate in some areas. Most of the water used for rural domestic purposes is obtained from pumped groundwater. A "Groundwater Availability Map", developed as part of this study (see Appendix II), gives a general indication of the available groundwater supply(ies) and its quality. The possibility of increasing livestock water has been improved with the introduction of artificial catchment basins and the increased use of wells, pipelines and watering troughs.

There is very little opportunity to construct quality reservoirs in the Basin. Water is scarce and oversubscribed in some areas. Most of the good sites have already been developed. However, there are 26 sites studied by USDA that may have potential for future construction. These include 9 irrigation/recreation reservoirs, 13 single purpose recreation reservoirs, 1 site for the possible utilization of intermittent storage in closed basins, and 3 single purpose sediment control sites. Although all these sites offer potential, it may be that resources would most profitably be devoted to improving existing facilities rather than creating new ones.

Water budgets were developed for 18 selected water use areas (WUA) and for the Total Basin. They are based on the best estimates of water supply, water use and (stream) outflow. Data is presented for both present (1975) and future (1990, 2000 and 2020) conditions.

DESCRIPTION OF BASIN [1/]

PHYSICAL DESCRIPTION

The Little Colorado River Basin includes those areas of Arizona and New Mexico drained by the Little Colorado River and its tributaries. About 80 percent of the study area is in Arizona and includes parts of Coconino, Navajo and Apache Counties. About 20 percent is in New Mexico and includes parts of San Juan, McKinley, Valencia and Catron Counties. The area is noted for highly erodible soils, long nearly barren slopes, sediment-laden washes and wind-blown sand. The study area is bound on the east by the Rio Grande Basin, on the south by the Gila River Basin and on the north by the San Juan Basin. The Little Colorado River joins the Colorado River in the Grand Canyon on the northwest edge of the Basin (see Location Map).

The Basin is about 245 miles long and 158 miles wide at the widest point. The mainstem of the Little Colorado River is entirely in Arizona, has a channel length of 356 miles and total drop of about 6,300 feet from its head in the White Mountains to its confluence with the Colorado River.

1/ A detailed description of the Basin, including socio-economic base, is given in Appendix I.

About 0.23 percent of the Basin (39,020 acres) is cropland (.20 percent, or 34,820 acres, of the area is irrigated cropland). In Arizona, most of the cropland (29,870 acres) is irrigated; whereas in the New Mexico portion only about 54 percent (4,950 acres) is irrigated. Approximately 59 percent of the area (10,283,280 acres) is rangeland with either grass or grass-shrub vegetation; 39 percent (6,725,960 acres) is forest or woodland; and 1 percent (208,700 acres) is urban, remote subdivisions or water.

Approximately 10 percent of the Basin is State Trust Lands; 4 percent is federal land administered by the Bureau of Land Management; 14 percent is in the national forests; 1 percent is other federal lands; 48 percent is Indian Reservations; and 23 percent is privately owned. (See Land Ownership Map.)

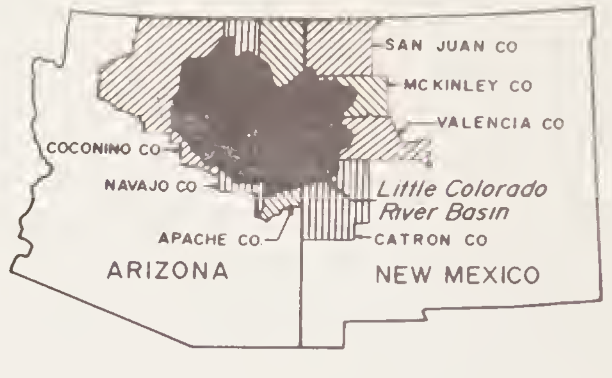
The climate is arid in the lower elevations and subhumid in the mountains. Precipitation averages eight inches per year on the drier parts of the plains to 32 inches in the mountains. (See Normal Annual Precipitation Map.) Rainfall is characteristically erratic, ranging from an entire lack of precipitation for long periods to storms of exceedingly high intensity. The mean annual temperature is 55° F. at Winslow and Tuba City to 46° F at Flagstaff. Temperature extremes in the area have ranged from over 100° F. to less than -50° F.

The Little Colorado River Basin is in the Colorado Plateau physiographic province. Most of the area consists of dissected plains over sedimentary bedrock. It comprises plateaus, valleys, buttes and mesas. The general surface is interrupted locally by high volcanic mountains and deeply incised canyons. Locally along the Little Colorado River are large areas of geologically eroding shale, mudstone and sandstone, forming what is known as the "Painted Desert" (badlands).

The highest elevations are the result of uplift and volcanic activity. The highest mountains in the Basin are the White Mountains (Baldy Peak, 11,403 feet) and the San Francisco Peaks (Humphrey's Peak, 12,633 feet). The lowest point in the Basin is about 2,900 feet in the gorge of the Little Colorado River at its junction with the Colorado River.

The Basin contains parts of four major land resource areas. The Colorado and Green River Plateaus extend over most of the Basin. A minor amount of the Sonoran Basin and Range is at the confluence of the Little Colorado and the Colorado Rivers. The Arizona and New Mexico mountains extend over the mountainous southern and eastern parts, and the New Mexico and Arizona Plateaus and Mesas occupy the plains of New Mexico and adjacent parts of Arizona.

Most of the soils are well drained and alkaline. A major part of the upland soils of the plains are developed in sediments and are deep with sandy loam surfaces. The rest of the plains soils are either deep clayey soils of the flood plains or shallow soils on sandstone, limestone or shale. Much of the shale is saline in nature. The mountain soils are generally clayey and shallow to moderately deep over basalt, ash or cinders. The plains soils are



LOCATION MAP

15020004 Hydrologic Unit Code, U.S. Water Resources Council

LOCATION MAP
LITTLE COLORADO RIVER BASIN
ARIZONA AND NEW MEXICO

JUNE 1980

10 0 10 20 MILES

SCALE 1:1,000,000

BY

ARIZONA WATER COMMISSION

NEW MEXICO STATE ENGINEER

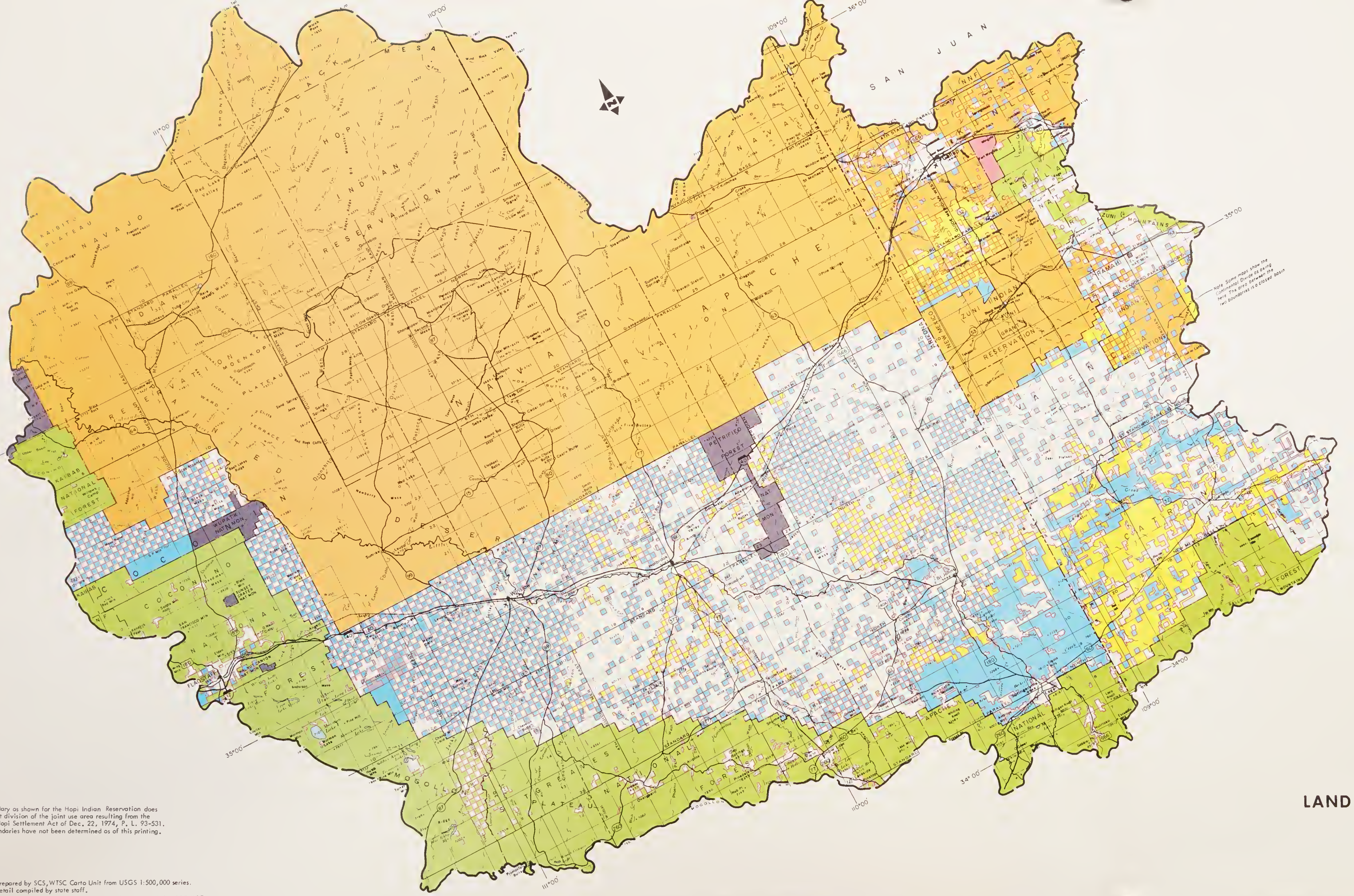
AND

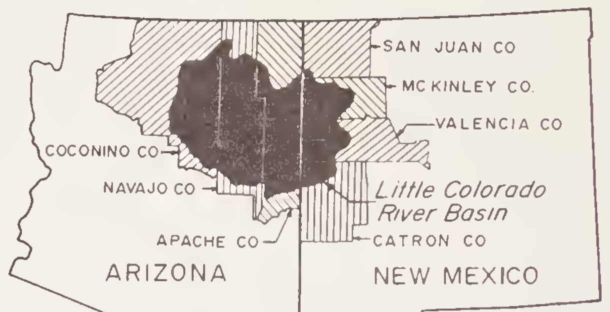
U.S. DEPARTMENT OF AGRICULTURE

Note:
The boundary as shown for the Hopi Indian Reservation does not reflect division of the joint use area resulting from the Navajo-Hopi Settlement Act of Dec. 22, 1974, P. L. 93-531. Final boundaries have not been determined as of this printing.

Source:
Base map prepared by SCS, WTSC Carto Unit from USGS 1:500,000 series. Thematic detail compiled by state staffs from previously published SCS data.
U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

USDA-SCS-PORTLAND OR 1980





LOCATION MAP

LAND OWNERSHIP AND ADMINISTRATION

LITTLE COLORADO RIVER BASIN

ARIZONA AND NEW MEXICO

1979

10 0 10 20 MILES

SCALE 1:1,000,000

Note:
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Base map prepared by SCS, WTSC Carto Unit from USGS 1:500,000 series.
Thematic detail compiled by state staff.

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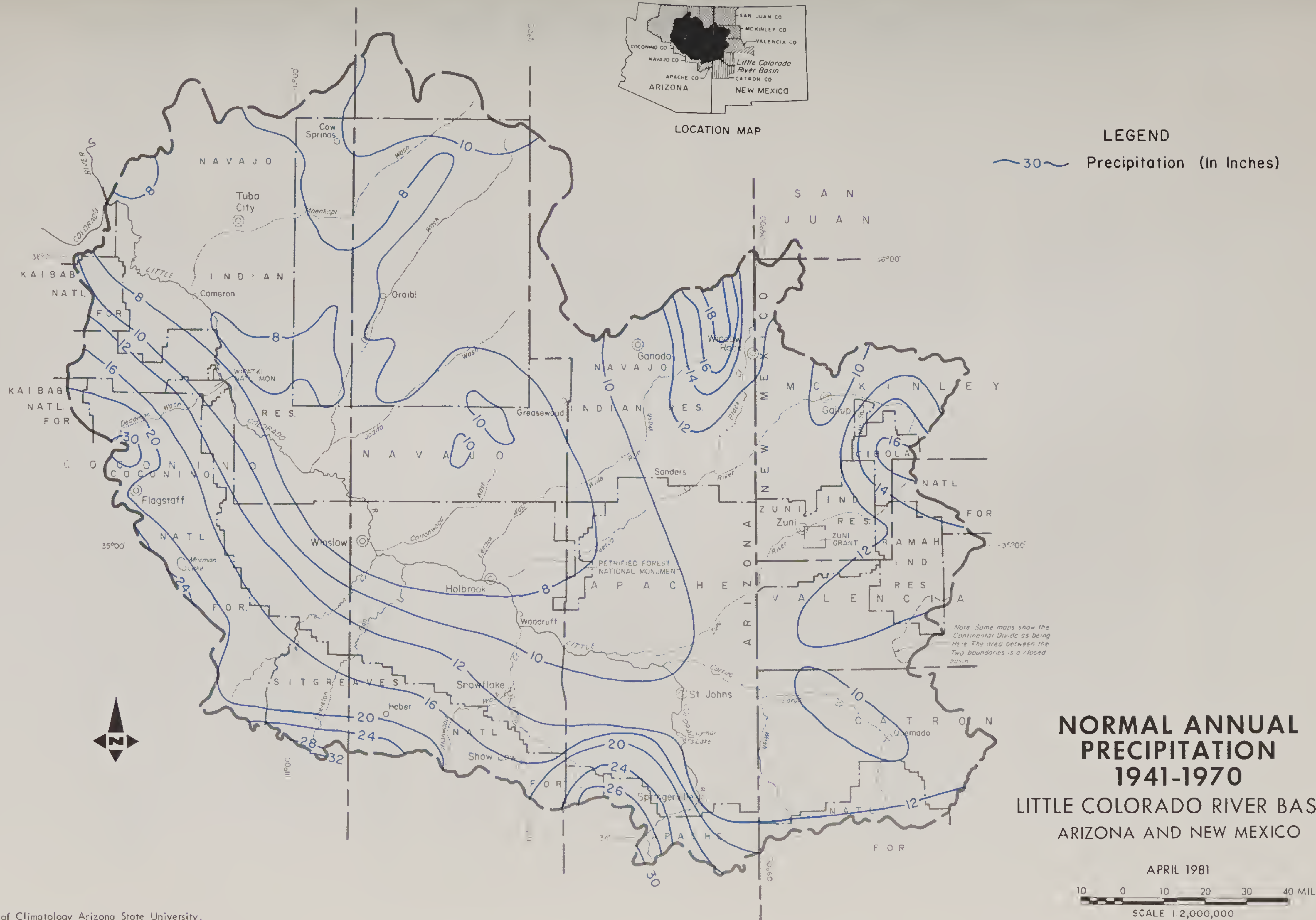

NORMAL ANNUAL PRECIPITATION 1941-1970

LITTLE COLORADO RIVER BASIN

ARIZONA AND NEW MEXICO

APRIL 1981

10 0 10 20 30 40 MILES

SCALE 1:2,000,000

Source:
Laboratory of Climatology Arizona State University.
Climatography of the U.S. (New Mexico).
Base map prepared by SCS, WTSC Carta Unit from USGS 1:500,000 series.
Thematic detail compiled by state staff.

U S DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

USDA SCS PORTLAND OR 1981

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generally gently rolling, whereas the soils of the mountains are moderately sloping to steep. The irrigated areas are all on alluvial sloped or flood plains. (See General Soil Map.)

Vegetation communities vary from the Great Basin Desert Scrub at the lowest elevations to the Montane Conifer Forest which occurs in the higher elevation of the Basin. Saltbush-grass communities occur along the valleys on the more alkaline soils. The Juniper-Pinyon Woodland community is found at medium elevations. Extensive grassland occurs in the area between the Great Basin Desert Scrub and the Juniper-Pinyon Woodland communities. (See Vegetation Communities Map.)

Plant cover and precipitation are correlated with elevation. The higher elevations have the greatest plant cover, highest rainfall and, conversely, the least erosion, with the notable exception of the Black Mesa, an area of incised sedimentary strata with high erodibility. Erosion on the "badlands" is dominantly a natural geologic process. In general, erosion is most serious in the plains and desert grassland areas.

The scenery is spectacular and includes the Petrified Forest National Park, Painted Desert, Meteor Crater, San Francisco Peaks and the White Mountains. Nearby are Grand Canyon National Park, Glen Canyon National Recreation Area, Rainbow Bridge National Monument, Monument Valley and Canyon de Chelly National Monument.

SOCIO-ECONOMIC BASE

The economy of the Basin was originally founded on livestock production and forestry. In recent decades, forest products and tourism have contributed a large share to the income of the people. Other important sectors are: government, manufacturing, mining, public utilities, agriculture and construction. Recreation and hunting are also important.

Coal, natural gas, helium, uranium, vandium, bentonite, halite and sand and gravel are the most important mineral resources being mined in the Basin. Silicate, diatomaceous earth, limestone, manganese and potash deposits are known but are not being mined.

Interstate Highway 40 runs the entire length of the Basin and is traveled by more than a million cars annually. The mainline Santa Fe Railway between Kansas City and Los Angeles follows the same general route.

The principal communities are Flagstaff, Winslow and Holbrook in Arizona, and Gallup in New Mexico. All are situated along Interstate Highway 40. Other communities include Snowflake, Show Low, St. Johns, Springerville, Eagar and Window Rock in Arizona; and Quemado and Zuni in New Mexico.

The population is expected to grow from about 162,200 in 1975 to around 426,000 in 2020 (Table 1). This growth can be partially attributed to a general trend of migration from north and northeastern urban areas to rural areas of the sunbelt states. In McKinley and Valencia Counties of New Mexico the higher national demand for coal and uranium will also contribute to

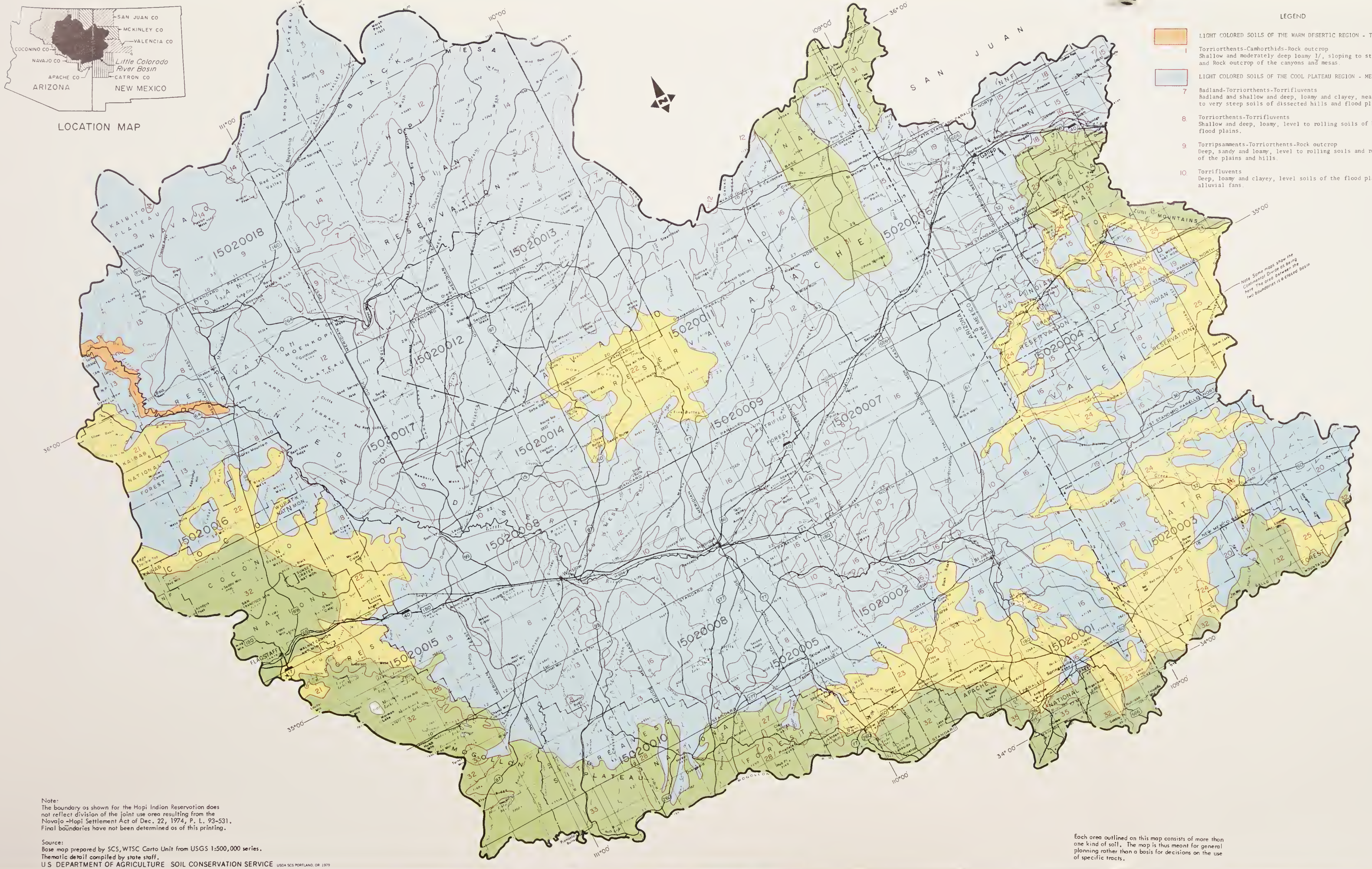
TABLE 1

POPULATION INSIDE AND OUTSIDE LITTLE COLORADO RIVER BASIN
BY COUNTY, 1975 AND PROJECTIONS

(COUNTYWIDE & BASIN DATA)

Item	1975	1990	2000	2020
	-------------	1,000's	-------------	
Apache County, AZ	41.0	64.9	79.0	95.9
In	23.9	34.0	41.7	53.8
Out	17.1	30.9	37.3	42.1
Coconino County, AZ	67.3	108.8	137.6	180.1
In	48.0	75.5	93.0	125.0
Out	19.3	33.3	44.6	55.1
Navajo County, AZ	59.0	91.0	114.2	149.6
In	49.0	74.4	91.2	114.6
Out	10.0	16.6	23.0	35.0
ARIZONA TOTAL	167.3	264.7	330.8	425.6
In	120.9	183.9	225.9	293.4
Out	46.4	80.8	104.9	132.2
Catron County, NM	2.3	5.9	9.3	11.9
In	.5	.5	.6	.6
Out	1.8	5.4	8.7	11.3
McKinley County, NM	51.2	70.8	88.2	145.0
In	39.8	60.5	76.2	130.0
Out	11.4	10.3	12.0	15.0
Valencia County, NM	46.0	25.9	86.5	147.4
In	1.0	1.0	1.0	2.0
Out	45.0	74.9	85.5	145.4
NEW MEXICO TOTAL	99.5	152.6	184.0	304.3
In	41.3	62.0	77.8	132.6
Out	58.2	90.6	106.2	171.7
SIX COUNTY TOTAL	266.8	417.3	514.8	729.9
In	162.2	245.9	303.7	426.0
Out	104.6	171.4	211.1	303.9

Source: Arizona Department of Water Resources with adjustments by USDA-ERS to reflect population inside the Little Colorado River Basin.



LEGEND

LIGHT COLORED SOILS OF THE WARM DFSERTIC REGION - THERMIC

1 Torriorthents-Camhorthids-Rock outcrop
Shallow and moderately deep loamy 1/, sloping to steep soils and Rock outcrop of the canyons and mesas.

LIGHT COLORED SOILS OF THE COOL PLATEAU REGION - MESIC

7 Badland-Torriorthents-Torrifluvents
Badland and shallow and deep, loamy and clayey, nearly level to very steep soils of dissected hills and flood plains.

8. Torriorthents-Torrifluvents
Shallow and deep, loamy, level to rolling soils of hills and flood plains.

9. Torripsamments-Torriorthents-Rock outcrop
Deep, sandy and loamy, level to rolling soils and rock outcrop of the plains and hills.

10. Torrifluvents
Deep, loamy and clayey, level soils of the flood plains and alluvial fans.

12 Torriorthents-Camborthids-Torrifluvents
Moderately deep to deep, loamy, level to undulating soils of the uplands and flood plains.

13. Torriorthents-Haplargids-Rock outcrop
Shallow, loamy and clayey, level to rolling soils and rock outcrop of the plateaus.

14. Torriorthents-Rock outcrop-Haplargids
Shallow, loamy and clayey, sloping to steep soils and rock outcrop of the hills.

15. Rock outcrop-Torriorthents-Haplargids
Rock outcrop and shallow to deep, loamy, level to steep soils of the canyons and plains.

16. Haplargids-Torripsamments-Torrifluvents
Deep, loamy and sandy, level to undulating soils of the plains and flood plains.

17 Torriorthents-Rock outcrop
Shallow, loamy, sloping to rolling soils and rock outcrop of the dissected plateaus.

18. Camborthids-Torriorthents
Shallow to deep, loamy and clayey, undulating to sloping soils of the plains and hills.

19. Haplargids-Torriorthents-Rock outcrop
Shallow to deep, loamy and clayey, level to rolling soils and rock outcrop of the plains and hills.

20. Haplargids
Deep, loamy and clayey, level to sloping soils of the plains.

LIGHT AND MODERATELY DARK COLORED SOILS OF THE COOL PLATEAU REGION - MESIC

21. Argiustolls-Haplustalfs
Shallow to moderately deep, clayey, undulating to sloping soils of the hills.

22 Calciustolls-Haplustolls-Argiustolls
Shallow to moderately deep, loamy and clayey, undulating to sloping soils of basalt controlled mesas and cinder cones.

23. Argiustolls-Chromusterts
Shallow to deep, clayey, nearly level to sloping soils of basalt plains and hills.

24. Torrifluvents-Haplargids-Haplustolls
Deep, loamy and clayey, level to sloping soils of the flood plains and plains.

25. Argiustolls-Haplustalfs-Rock outcrop
Shallow to deep, loamy and clayey, level to sloping soils and rock outcrop of basalt-capped mesas.

MODERATELY DARK AND DARK-COLORED SOILS OF THE COOL TO COLD MOUNTAIN REGION - MESIC AND FRIGID

26. Haplustolls-Haplustalfs
Shallow to moderately deep, loamy and clayey, undulating to steep soils of the hills.

27 Argiustolls-Haplustalfs-Ustochrepts
Deep, loamy and clayey, sloping to rolling soils of hills.

28. Eutroboralfs-Haplustalfs-Ustorthents
Shallow to deep, loamy and clayey, undulating to very steep soils of mountains.

29. Rock outcrop-Haplustolls-Argiustolls
Shallow, loamy and clayey, rolling to very steep soils of hills.

30. Eutroboralfs-Argiborolls
Shallow to moderately deep, loamy and clayey, sloping to steep soils of the mountains.

31 Eutroboralfs-Ustorthents
Shallow to deep, loamy and clayey, sloping to steep soils of the mountains.

32 Argiborolls-Cryoborolls-Ustorthents
Moderately deep to deep, loamy, sloping to steep soils of the mountains.

33. Eutroboralfs
Moderately deep and deep, clayey, level to sloping soils of the mountains.

35. Cryoborolls
Deep and moderately deep, loamy and clayey, level to sloping soils of the mountain meadows.

1/ Texture refers to the subsoil or underlying layer between 10-40 inches or a restricting layer.

Note:
The boundary os shown for the Hopi Indion Reservotion does not reflect division of the joint use oreo resulting from the Novojo -Hopi Settlement Act of Dec. 22, 1974, P. L. 93-531. Final boundaries have not been determined os of this printing.

Source:
Bose mop prepored by SCS, WTSC Carto Unit from USGS 1:500,000 series.
Thematic detoil compiled by stote stoff.
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Eoch oreo outlined on this mop consists of more thon one kind of soil. The mop is thus meont for generol plonning rother thon o bosis for decisions on the use of specific tracts.

GENERAL SOIL MAP
LITTLE COLORADO RIVER BASIN
ARIZONA AND NEW MEXICO

1979

10 0 10 20 MILES
SCALE 1:1,000,000

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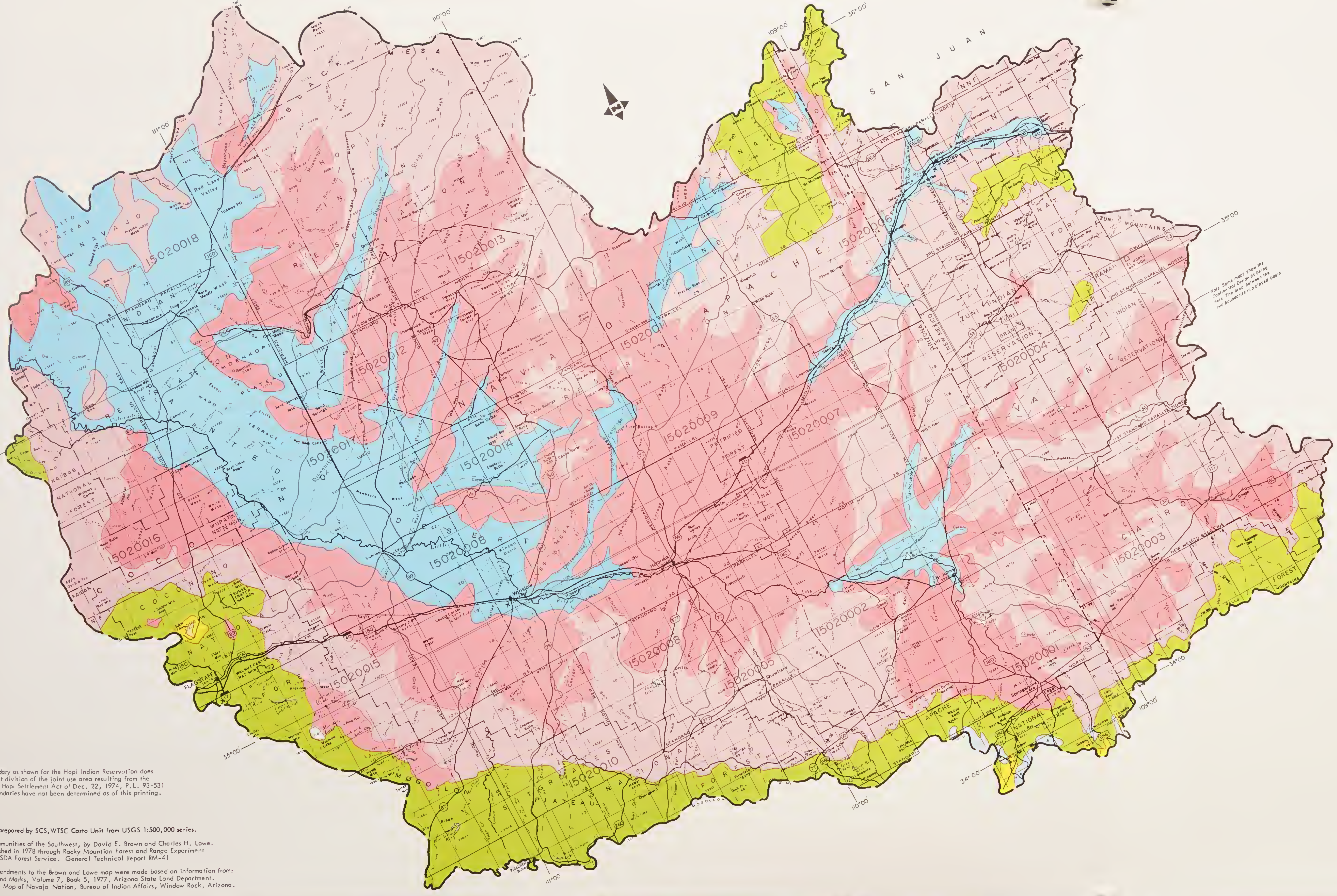

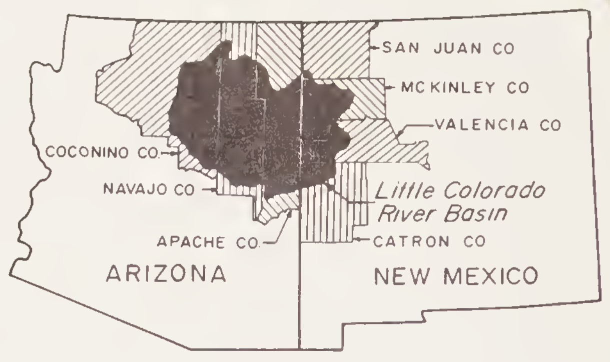

LOCATION MAP

LEGEND

- Alpine Tundra
- Spruce-Alpine Fir Forest
- Montane Conifer Forest
- Juniper - Pinyon Woodland
- Plains and Desert Grassland
- Mountain Meadow Grassland
- Great Basin Desert Scrub
- 15020004 Hydrologic Unit Code U S Water Resource Council

NOTE: Description of vegetation communities are in the Fish and Wildlife Section of the report.

Note:
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Source:
Base map prepared by SCS, WTSC Carto Unit from USGS 1:500,000 series.

Biotic Communities of the Southwest, by David E. Brown and Charles H. Lowe. Map published in 1978 through Rocky Mountain Forest and Range Experiment Station, USDA Forest Service. General Technical Report RM-41

Several amendments to the Brown and Lowe map were made based on information from: Arizona Land Marks, Volume 7, Book 5, 1977, Arizona State Land Department. Forest Type Map of Navajo Nation, Bureau of Indian Affairs, Window Rock, Arizona.

VEGETATION COMMUNITIES
LITTLE COLORADO RIVER BASIN
ARIZONA AND NEW MEXICO

1980

10 0 10 20 MILES
SCALE 1:1,000,000

U.S DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA-SCS-PORTLAND OR 1980

population increase. In Coconino County, Arizona, there will be significant growth in tourism, education (Northern Arizona University), lumbering and manufacturing. Recently there has been an increase in second homes in some of the scenic areas. This trend could be seriously dampened if gasoline costs continue to increase.

The expansion or new construction of electric generating stations is currently stimulating the economies of certain areas of Navajo and Apache Counties. The Arizona Public Service Company is adding a fifth unit at its site two miles east of Joseph City, Arizona. The Salt River Project is constructing a new facility north of St. Johns, Arizona, and the Tucson Electric Power Company is constructing the first of three units to be built at a site 10 miles north of Springerville, Arizona. These are all coal-fired plants that will result in a fairly strong multiplier linkage to the rest of the economy.

Coconino, Navajo and Apache Counties account for $52,000,000 of Arizona's $97,000,000 of taxable income from timber sales.[1/] This industry is very important in the Basin's economy. However, its expansion depends largely on improvements in management that bring about increased production per acre. Much of the timber harvest is controlled by the U.S. Forest Service, based on long-term conservation and management goals.

There may be opportunities for expansion of timber industries. Such expansion, utilizing local raw materials, would have a higher economic multiplier effect than expansion in an industry which must purchase raw materials from outside the Basin. For the same reason, growth in the construction sector which utilizes locally produced timber products would have a good multiplier effect on the rest of the economy. An example would be more home building due to increases in either the permanent or seasonal population.

The value of the main crops produced in the six major counties in 1978 (excluding San Juan County, New Mexico), according to rank by value of production, were hay ($3,900,000), corn ($639,000), and sorghum ($242,000). Most of the crop production shown for New Mexico counties was outside the Basin.

Range cattle production is the main livestock enterprise. Value of production for the entire six counties in both states dropped from about $82 million in 1974 to about $63 million in 1978. Much range is overgrazed and cattle numbers should be adjusted to balance grazing with forage production. Grazing systems should be applied to improve the condition of the various range sites.

Sheep production is also important in both states. The value of sheep produced in the three Arizona counties in 1974 was about $6 million; in New Mexico, about $3.7 million. In 1978 these figures had increased to $7.4 million and $5.7 million, respectively.

1/ Arizona Statistical Abstract, 1979.

Councils of Government's staff people are available in both Arizona and New Mexico to assist city and county officials to foresee and plan for orderly growth. They also help communities locate sources of funds to help meet local needs. The RC&D Program coordinated by the Soil Conservation Service also can assist in planning and locating financial support for community resource conservation and development projects.

PROBLEMS AND NEEDS

LAND USE AND ADMINISTRATION

There is competition for land among urban, industrial, agricultural, grazing, timber, wildlife and recreational interests. Land resource problems will become increasingly more complex as the Basin's population increases.

Although irrigated farm lands and urban areas represent only a small percentage of the total Basin, there is still some competition between these two land uses. Some of the irrigated lands near population centers are classified as "prime" farm lands and it is recognized that the attributes of prime farm land also cause it to be a most likely candidate for urban and suburban development. Three example areas in the Basin where prime farm land is being converted to urban are: Snowflake-Taylor, St. Johns-Lyman, and Springerville-Eagar. Some lands are also being developed into remote subdivisions, particularly near Holbrook, St. Johns, Show Low and Snowflake.

Timber has always been of importance to the local users and is becoming of increasing importance. Arizona's growing population and economy are generating ever increasing demands for forest and woodland products. Together with these demands are demands for more wilderness, recreational developments, and wildlife areas. Since most of the areas desirable for these latter uses are on forest lands, this will affect the management of these lands for timber production.

The land use history has been one of heavy grazing by both sheep and cattle. Both Juniper-Pinyon Woodland and Plains and Desert Grasslands are used for this purpose, as well as most other major vegetation communities. Livestock grazing is an important segment of the Basin's economy. Overgrazing by livestock has been blamed for much of the erosion that is occurring in parts of the Basin.

One of the main factors adding to the difficulty in solving the land resource problems and in improving the resource base is the complex land ownership pattern in the Basin. The southern part is national forest, the northern part is Indian Reservations, and the intervening part is a mixture of private, state and federal ownership.

Much of the land in the Basin is owned or is under the control of the federal government. These include lands administered by the Bureau of Land Management (BLM), Forest Service (FS), and Bureau of Indian Affairs (BIA) (Indian Trust Lands). The state(s) also owns a large portion. Only about 23 percent is in private ownership, and some of this is within national forest boundaries and

has only limited use. The high percentage of land under government control has affected the development of the Basin.

The landownership pattern has also caused some conflicts in the management of the land resources. The checkerboard pattern on much of the state, BLM and national forest lands has made it difficult to effectively manage these lands. This pattern resulted when alternate sections of land on each side of a railroad were granted to the railroads to aid westward expansion. Also, four sections of land per township were granted to each state at the time of statehood for an aid to education.

Another conflict yet to be resolved is what effect the Navajo-Hopi Settlement Act of December 24, 1977, Public Law 93-531, will have upon the management of land resources within the Basin. Indian lands presently comprise nearly 59 percent of the Basin. Two hundred and fifty thousand (250,000) acres of new Indian lands were authorized under Section 11 of the stated act. In July 1980, the act was amended by Public Law 96-305 (July 8, 1980) and gave the Navajo Tribe the option to buy an additional 150,000 acres. None of the new lands can be north or west of the Colorado River, nor can more than 35,000 acres be in New Mexico. Further, the land must be within 18 miles of the 1934 Navajo Reservation boundary. With the stated conditions, most of the new lands probably will be within the Little Colorado River Basin. The exact physical and social effects of this transfer of land is yet to be realized.

SOCIO-ECONOMIC

One of the major social problems in the Basin is the unemployment rate on Indian Reservations. The Indians living on reservations constitute a virtually untapped labor resource. A survey made on the Navajo Reservation by the Arizona State Employment Service indicates there are a large number of unemployed and underemployed Indians. Underemployment on the Navajo Reservation is approximately 72 percent and unemployment rates run as high as 45 to 50 percent. Factors contributing to these facts are:

1. Isolation. There is a sparse population in a large area with relatively poor transportation and communication facilities on the Reservation.

2. A high proportion of seasonal farm workers in the Indian labor force.

3. Low level of formal education.

4. Language barrier.

5. Lack of training in occupational skills.

Another major problem in the Basin is the out-migration of its young people. They leave for increased employment opportunities and more active social atmosphere of metropolitan areas. The loss of youth upsets the natural succession in the community and increases the concentration of people in metropolitan areas. One of the concerns of Basin residents is whether the location of major industries in the area will be enough to alleviate the out-migration of its young people.

The out-migration, however, is offset to some extent by the in-migration of people from outside the Basin. In fact, one of the primary socio-economic problems facing communities in the Basin is to plan for orderly development. Industry and population are moving into the sunbelt states. Northern Arizona and New Mexico hold high appeal to many from outside the states and from cities within Arizona and New Mexico.

If there is rapid population or industry buildup in any particular area, there is a potential for pollution. Visual, air and water quality can be detrimentally affected if development is not planned, or if zoning and building codes are not passed and effectively administered. Recently there has been an increase in second homes in some of the scenic areas of the Basin. The peak summer migration to some of the more popular recreational areas and the development of summer homes has caused problems with pollution and has reduced the environmental quality of some areas.

Seasonal variations in employment within the Basin are significant. Employment peaks in July and August and dips in December and January because of cold, snowy winters. The lumber and paper industries, for example, must stockpile logs during the summer so as to operate throughout the year.

WATER RESOURCES

Water is a scarce resource. Competition for water is a fact. Tradeoffs must be considered seriously. In some cases restrictions on use may be required. The need for water development is increasing. The major water use is for irrigated agriculture, accounting for more than 60 percent of the Basin's total water withdrawal. Water used for industry is expanding; water used for domestic purposes accounts for only a small percentage of the total withdrawal, but this percentage will increase as the population grows.

Some of the irrigated areas are short of water in some years. The amount of land under irrigation fluctuates with the water supply. As is usual in the southwest, there is more land suitable for irrigation than there is water available. A "critical groundwater area" has been established in the Holbrook vicinity that curtails the drilling of new irrigation wells within its boundaries. There is very little opportunity to increase supplies through the construction of new reservoirs because of existing water rights and other factors.

Conflicts over water rights have prevented the development of many reservoir sites, particularly in the White Mountains on the headwaters of the Little Colorado River above Springerville and St. Johns. The Arizona Game and Fish Department has attempted to obtain storage rights for fish and wildlife reservoirs at several sites in this area. These sites include Slade and Atcheson Lakes, the Sheep Springs site, Bigelow Crossing, Nutrioso Section 36 site, and possibly others. The applications have been refused upon protest by downstream users based on Title 45-172, Arizona Revised Statutes. Based on this statute, the written consent of downstream users is required even if irrigated lands are purchased with the intent of transferring irrigation water for these lands to upstream storage or if storage is purchased outright.

In some cases, storage reservoirs can be constructed for more than one purpose, e.g., irrigation, recreation and fish and wildlife. Fluctuating water levels on irrigation reservoirs, however, can have a detrimental effect on the use of the reservoir for fish and wildlife purposes. In extreme cases, fluctuating water levels can result in a total loss of fish population during periods of drought.

Fluctuating water levels can also cause the structure to be of low quality for waterfowl habitat. The widespread use of existing surface water developments for recreational purposes has limited the management of these same reservoirs for fish and wildlife purposes.

As the population of the Basin increases, there will be increasing pressure to convert present surface water supplies from such uses as irrigation to recreation and municipal and industrial (M&I) purposes. The use of water for M&I purposes is expected to more than triple by the year 2020.

Groundwater use for industrial purposes is expected to increase in the Basin. Presently, two new steam electric power generation stations are under construction and the power plant at Joseph City is being expanded. The two new power plants are in the Springerville-St. Johns area and are projected to become the major user of groundwater in this area. This use may conflict with the development of groundwater in this area for other purposes.

With the development of power generating stations, there has also been an increase in the demand for coal production. Some coal, for example, is stripped mined in the Black Mesa area and transported through a slurry pipeline for steam power generation outside the Basin. The use of the water for this purpose limits its availability for other purposes.

Other competition for water in the Basin is for livestock. Although the amount of water that is actually consumed by livestock is rather small, almost infinitestimal, the construction of livestock ponds can have a significant effect on the surface runoff in the Basin. This is due to the evaporation and seepage losses which occur at these structures.

Surface water is generally of suitable quality for most agricultural purposes. In some areas, settling ponds must be used to remove sediment and some waters are high in total dissolved solids. Poor quality surface water (1500 to 3000 mg/l TDS) is currently being used in St. Johns and Joseph City areas. In Woodruff, high sediment concentration is a problem.

The quality of groundwater is generally good south of the Little Colorado River, but often is of inferior quality north and east of the river. (See "Availability of Groundwater for Irrigation, Municipal or Industrial Use" maps in Appendix II.) Total dissolved solids concentrations of over 3,000 ppm have been recorded in wells north of Joseph City.

Some of the major problems related to the development of groundwater for municipal and industrial use include poor water quality, inadequate well yields and lack of funds for development. Inadequate storage and distribution systems are also a problem. Similar problems are encountered in the development of rural domestic and livestock water supplies.

The identification of problems and needs in the initial phase of this study indicated a shortage of surface water development for purposes of irrigation, flat water recreation, and fish and wildlife as areas of public concerns. Consequently, the investigation of additional water development projects, primarily storage projects, was included as a study objective. Evaporation and sedimentation, however, are two major constraints which must be considered in the development of any surface water resource. These combined with water rights problems make most surface water developments unattractive.

A need was expressed for the preparation of surface water budgets (including pumped groundwater) for 18 selected areas of the Basin. (See Water Budget Map in "Findings and Conclusions" section of this report.) The need was for additional information relative to the supply and use of water in these areas.

In summary, although there may still be some unallocated water, as the Basin continues to develop, the demand and competition for a finite water supply will increase, and there will be a need to allocate the available water resources to the various purposes.

EROSION AND SEDIMENT

The Little Colorado River, like many other areas in the arid and semiarid southwest, experienced a period of severe erosion in the late 1800's. Normal washes were changed to massive trenches. This was accompanied by desiccation and deterioration of millions of acres of land. However, judging from the name Colorado (Spanish for red) given to the river and the name of its main tributary, Puerco (meaning dirty), erosion and sediment have been prominent from before the days of the early Spanish explorers.

Severe erosion is still occurring in some of the alluvial valleys and on valley slopes of the Little Colorado, Puerco, and Zuni Rivers. About 5,300 miles of channel banks are experiencing moderate to severe erosion. In some parts of the Basin heavy grazing has been a major contributor to the acceleration of erosion. This erosion results in loss of land and soil productivity, creates gullies and releases soluble salts. Sediment degrades water quality, causes loss of storage capacity in reservoirs, plugs culverts and leads to increased flooding in many areas because of sediment deposition in water courses.

It has been estimated that the Little Colorado River contributed one percent of the water and 10 percent of the sediment load to the Colorado River prior to the construction of Glen Canyon Dam. Presently the percent of sediment is much greater. The average annual outflow of sediment from the Basin into the Colorado River above Lake Mead has been estimated at 10,200,000 tons. Soil erosion on irrigated land is not a major problem.

Stream gage measurements indicate that the Little Colorado River contributes 621,900 tons of salt to the Colorado River annually. However, it has been estimated that about 550,000 tons/year of this is from springs located near the river's mouth.

FLOODING

Flooding causes significant damage in urban and agricultural areas adjacent to the large drainages. Flooding on some of the smaller streams in localized areas is also a problem.

Eight areas in Arizona and two areas in New Mexico have been identified as having continuing flood problems. These include: Round Valley, Hay Hollow, Holbrook, Winslow, St. Johns, Navajo Indian Reservation, Flagstaff, and the Snowflake-Taylor-Shumway areas in Arizona; and the Gallup and Zuni Pueblo areas in New Mexico. The type and severity of the problems vary with location (Appendix III).

RECREATION

During the summer months, the cool pine forests in and adjacent to the Basin receive heavy recreation use, particularly from Phoenix and Tucson. This overtaxes the available camping, fishing and recreation areas. Increasing demands will result in more pressure for a shift in land use from timber production and grazing to more recreation facilities. Since much of the recreational use is water-oriented, there is a need to increase the number of water-based recreational facilities and improve existing facilities. This will result in increasing pressure to convert existing irrigation reservoirs to recreational purposes.

Other problems related to recreation include limited access to areas that are suitable for recreational use, lack of awareness of recreational opportunities and vandalism.

FISH AND WILDLIFE

The effects of past activities and land use practices have in many cases reduced and degraded the habitats of fish and wildlife. Long periods of heavy grazing by domestic livestock have resulted in the reduction of preferred forage plants utilized by wildlife. Livestock grazing has also reduced the vegetative cover required for the protection of young animals and birds. Protection of riparian vegetation within forests, woodlands and rangelands is critical to maintaining and improving wildlife habitat. Expansion of human population and great increase in recreational activities have also been detrimental to wildlife. Human-caused pollution in the forms of sediments and domestic sewage has lowered the capacity of many aquatic ecosystems to support desirable fish and wildlife populations. There is also a need for additional fishing opportunities in the Basin.

TIMBER

There are many complex and interrelated problems with reference to forest and woodland resources. Each year numerous trees are weakened, damaged or destroyed by insects and disease. A critical forest management activity involves the prevention and control of wildfires. Conflicting uses of timber land for wilderness, recreation and other uses will increase and intensify. There is a need for inventories and guidelines to develop forest and woodland

management plans. The public and sponsors of this study have expressed a concern for increasing timber production; while at the same time maintaining the environmental quality of the forest lands.

FINDINGS AND CONCLUSIONS

Following is a brief summary of the findings and conclusions for this study. For a more detailed discussion of the individual study items, the reader is referred to the four appendices published with this report.

WATER RESOURCES 1/

Water resources is composed of five separate but interrelated subsections: Irrigation, Municipal and Industrial Water Supply, Rural Domestic and Livestock Water Supply, Development of Surface Water Resources, and Surface Water Budgets (Including Pumped Groundwater). These will be discussed in turn.

Irrigation

There are 34,820 acres of irrigated land in the Little Colorado River Basin, including 29,870 acres in Arizona (of which 5,420 acres are native grass that are wild flooded) and 4,950 acres (1975) in New Mexico.

Alfalfa and legume-grass mixtures are the major crops produced. These crops are used for hay, and the latter is also used for pasture. Other main crops include corn, small grains, sorghum and vegetable crops.

The water supply is primarily from surface sources, althouth groundwater is used exclusively in some areas; and there is a small amount of irrigation with sewage reutrn flows. Surface water used for irrigation is either diverted directly onto croplands from streamflow or is stored in irrigation reservoirs. Major irrigation storage reservoirs in Arizona include Lyman Lake in Apache County (30,600 AF) and White Mountain Reservoir in Navajo County (2,390 AF). Major reservoirs in New Mexico include Ramah Reservoir (3,870 AF) and Black Rock Reservoir (2,600 AF).

The normal seasonal irrigation water withdrawal, not including storage or transmission losses, for Arizona is about 100,180 AF (64,950 acre feet of surface water and 35,230 acre feet groundwater) and for New Mexico is about 11,460 acre feet (11,450 acre feet of surface water and 10 acre feet groundwater)

Some irrigated areas are short of water in some years. The amount of land irrigated fluctuates with the water supply. There is little opportunity to increase surface water supplies, but there is potential for system improvements and better irrigation water management. (See Tables 2 and 3).

Conservation land treatment is needed on the irrigated lands in the Basin. Although soil erosion on irrigated lands is not a major problem, land treatment is needed to improve soil condition and efficiency of water use, and protect water quality. These needs include improvements in the off-farm

1/ See Appendix II for a detailed discussion of water resources in the Basin.

Table 2 - Projected Needs
Conservation Land Treatment and Off-Farm Conveyance System Improvements Needed
Little Colorado River Basin, Arizona and New Mexico

Water Use Area	Projection Year	Total 1/ Irrigated Acres	Conservation Cropping System (Acres)	Crop Reidue Mgmt. (Acres)	Minimum Tillage (Acres)	Pasture & Hayland Mgmt. (Acres)	OnFarm Irrigation Systems 2/ (Acres)	Irrigation Water Mgmt. (Acres)	Off-farm System Improvement (Linear Ft.)
Arizona	1990	24,450	860	860	860	5,270	7,570	9,540	364,360
	2000	24,450	100	100	100	2,350	4,230	6,070	308,270
	2020	24,450	0	0	0	480	1,470	2,690	208,070
New Mexico	1990	4,650	3,000	1,490	1,490	1,510	1,560	2,920	71,400
	2000	4,950	4,300	2,210	2,210	2,090	2,030	4,200	65,600
	2020	4,950	4,300	2,210	2,210	2,090	1,160	4,300	6,000
Total Basin	1990	29,100	3,860	2,350	2,350	6,780	9,130	12,460	435,760
	2000	29,400	4,400	2,310	2,310	4,440	6,260	10,270	373,870
	2020	29,400	4,300	2,210	2,210	2,570	2,630	6,990	214,070

1/ Does not include 5,420 acres of native grass in Arizona portion of Basin.
2/ Includes land leveling and smoothing, ditch lining, water measuring devices, or other improvements

Table 3 - Projected Effects
By Conveyance System Improvements and Conservation Land Treatment
Little Colorado River Basin, Arizona and New Mexico

Water Use Area	Projection Year	Irrigated Acres	Consumptive Irrigation Requirement 3/ (ac. ft.)	Off-Farm Conveyance Losses (ac. ft.)	On-Farm (ac. ft.)	Total Losses (ac. ft.)	Normal Withdrawal (ac. ft.)	Potential Change in Withdrawal from Present Conditions (ac. ft.)
Arizona	1990	24,450 1/	43,190	28,350	23,220	51,570	94,760	
	2000	24,450 1/	43,190	26,480	19,370	45,850	89,040	- 5,720
	2020	24,450 1/	43,190	23,250	16,260	39,510	82,700	-12,060
New Mexico	1990	2,520 2/	3,760	2,530	1,330	5,560	9,320	
	2000	2,520 2/	3,760	1,600	1,700	3,300	7,060	- 2,260
	2020	2,520 2/	3,760	1,570	940	2,510	6,270	- 3,050
Total	1990	26,970	46,950	30,880	24,550	57,130	104,080	
	2000	26,970	46,950	28,080	21,070	49,150	96,100	- 7,980
	2020	26.970	46,950	24,820	17,200	42,020	88,870	-15,110

1/ Does not include 5,420 acres of native grass in Arizona portion of Basin, therefore the values for irrigated acres, consumpive irrigation requirements, and withdrawals are different from those shown in Table 1-1, Appendix II, Section 1, "Irrigation".
2/ Base year irrigated acreage. Additional acreage irrigated when water supply is available. See Table 1-3A, Appendix II, Section 1, "Irrigation" for total acreage.
3/ Normal seasonal consumptive use minus effective precipitaion.

conveyance system, irrigation water management, onfarm improvements such as land leveling and smoothing, ditch lining, pipelines, and other conservation practices (Table 2).

There are three areas in Arizona (West Taylor, Springerville and Pinetop-Woodland) that have potential for development as Resource Conservation and Development Project Measures. Measure plans were developed for each of these areas which maximized national economic development (NED) and emphasized environmental quality (EQ). Each plan consisted of off-farm conveyance system improvements. The West Taylor system consists of 14,470 feet of PVC pipe and associated outlet structure, measuring meters, trash cleaners, valves, etc. The estimated installation cost for the improvements, including administrative cost, is $124,700.

The Springerville system consists of approximately 11, 800 feet of low head, buried, gravity flow, irrigation pipeline; a screened inlet structure; appropriate outlet structures and in-line valves and water control structures. Installation cost for these works of improvement was estimated at $63,200.

The recommended alternative for the Pinetop-Woodland project consists of 20,825 feet of PVC pipeline with appropriate inlet and outlet structures. The installation cost for this system was estimated to be $177,800.

Since all of these projects maximized national economic development and emphasized environmental quality, tradeoffs between various alternatives were not developed.

Although present irrigation efficiencies were not calculated for all irrigated lands in the Arizona portion of the Basin due to a lack of reliable data, it was estimated that with the proposed land treatment program the overall efficiency could increase to about 52 percent by the year 2020. In New Mexico, the proposed land treatment program could increase the overall efficiency from about 33 percent in 1975 to 60 percent in 2020.

The surface waters used for irrigation are generally of excellent quality. Dissolved-solid concentrations range from about 60 to 150 mg/l. Poor quality surface water, however, is currently being used in three separate areas in Arizona: St. Johns (Apache County), Woodruff and Joseph City (Navajo County).

The problem of prime farm lands being converted to urban or some other land use is a land management problem. Although specific land use designation is a prerogative of state and local officials, USDA is nonetheless concerned about the loss of such a valuable resource to non-agricultural uses.

Municipal and Industrial Water Supply

Over 65 percent of the estimated 162,200 population reside in cities and towns. These communities are served by numerous municipal, corporate, or investor-owned water systems. The adequacy of these system varies considerably, both with respect to total available water supply and to storage and distribution capacities.

The total water withdrawal for municipal and industrial purposes in 1975 amounted to about 15,600 acre feet. The depletion requirement for these purposes was estimated to be 7,800 acre feet, or 50 percent of the total withdrawal. The remainder was lost to deep percolation, evaporation, or other beneficial or non-beneficial consumptive uses. Table 4 summarizes present and future withdrawals by community, county and water use areas. Table 2-4 in Appendix II shows the communities which need their water supplies augmented or their storage and distribution systems replaced or modified.

The water quality varies with each community. Hardness ranges from soft to hard; predominantly the water is hard but acceptable for M&I use. Locally, the concentrations of sediments, fluorides and dissolved solids may exceed recommended limits. The groundwater is highly mineralized in the St. Johns area and in the area north and northeast of Holbrook and Winslow. Poor quality groundwater has been experienced in the Keams Canyon and Witch Well study areas.

The communities of the Basin have been and will be faced with the problems of peak use shortage or simply a water shortage. Water supply owners and managers have begun to adopt procedures aimed at conserving water. M&I water use can be reduced by controlling growth or the per capita use rate. Growth may be controlled by limiting permits, restricting utility expansion or discouraging development in general. Per capita use rates may be controlled by attracting industries with low water use, promoting lawn reduction, or promoting multi-family developments. Other conservation techniques that may be used include: use of low water using fixtures and appliances, leak detection and repair, education, wastewater reuse, metering, pressure reduction and pricing.

In Arizona, there are very few opportunities in the Basin for increasing M&I water supplies from surface water because of prior appropriation (primarily for irrigation) and limited runoff conditions.

Surface water is available for M&I use in the New Mexico portion of the Basin. Several reservoirs exist along the Zuni River and its tributaries. Also, about 7,500 acre feet of surface water have been allocated for use by the City of Gallup from the San Juan River Basin.

Another alternative source of surface waters, in both states, is that of conversion of use. As the demand for M&I increases and other alternative sources become scarce or more expensive, there will be increasing pressure to convert present surface water supplies from such uses as irrigation to M&I purposes.

For most communities, groundwater has proven to be the least costly alternative for water supply development. In New Mexico, present M&I well fields are located in alluvial aquifers that are stream connected. In Arizona, well fields are located in various multiple aquifers systems. A general indication of the availability and quality of groundwater in the Basin is shown on map(s) entitled "Availability of Groundwater for Irrigation, Municipal or Industrial Use in the Little Colorado River Basin" in Appendix II.

TABLE 4: PRESENT & PROJECTED POPULATION & M&I WATER WITHDRAWALS
LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO

LOCATION	Water Use Area	POPULATION 1/ 1975	1990	2000	2020	WATER DEMANDS (acre-feet per year) 1975 2/	1990 3/	2000 3/	2020 3/
Apache Co., Arizona									
Ft. Defiance, Window Rock & St.Michaels	CHN	5,400	7,780	9,990	17,400	621	894	1,149	2,000
Greasewood	CHN	1,200	1,340	1,440	1,690	214	240	257	300
Kin-Li-Chee	CHN	400	450	480	560	47	53	56	66
Subtotal	CHN	7,000	9,570	11,910	19,650	882	1,187	1,462	2,366
Chambers/Sanders	PRZ	385	700	850	975	112	204	247	284
Navajo	PRZ	100	210	270	335	20	42	53	67
Witch Well	PRZ	200	460	590	700	11	26	33	39
Subtotal	PRZ	685	1,370	1,710	2,010	143	272	333	390
St. Johns	STJ	1,840	4,500	5,110	6,340	235	575	653	811
Subtotal	STJ	1,840	4,500	5,110	6,340	235	575	653	811
Eagar	WHM	1,960	3,350	4,700	5,800	175	299	420	518
Greer	WHM	50	75	100	120	36	54	72	87
Nutrioso	WHM	20	70	70	70	2	3	3	3
Springerville	WHM	1,420	2,350	3,280	4,050	180	297	416	513
Vernon	WHM	115	115	115	115	7	7	7	7
Subtotal	WHM	3,565	5,960	8,265	10,155	400	660	918	1,128
Concho	CON	510	950	1,120	1,400	72	130	154	192
Subtotal	CON	510	950	1,120	1,400	72	130	154	192
TOTAL COUNTY		13,600	22,350	28,115	39,555	1,732	2,824	3,520	4,887

--See Footnotes at end of table--

TABLE 4: PRESENT & PROJECTED POPULATION & M&I WATER WITHDRAWALS
LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO
(continued)

LOCATION	Water Use Area	POPULATION 1/ 1975	1990	2000	2020	WATER DEMANDS (acre-feet per year) 1975 2/	1990 3/	2000 3/	2020 3/
Coconino Co., Arizona									
Leupp	HOP	900	1,230	1,550	2,300	102	140	175	263
Subtotal	HOP	900	1,230	1,550	2,300	102	140	175	263
Flagstaff	SFP	31,370	47,920	57,970	78,000	3,977	6,055	7,338	9,874
Subtotal	SFP	31,370	47,920	57,970	78,000	3,977	6,055	7,338	9,874
Moenkopi	TUB	1,050	1,440	1,800	2,700	117	160	201	302
Tuba City	TUB	4,600	7,450	9,350	12,300	731	1,185	1,487	1,957
Subtotal	TUB	5,650	8,890	11,150	15,000	848	1,345	1,688	2,259
TOTAL COUNTY		37,920	58,040	70,670	95,300	4,927	7,540	9,201	12,396
Navajo Co., Arizona									
Hotevilla	BLM	900	1,050	1,200	1,500	101	118	135	168
Keams Canyon	BLM	290	290	290	290	24	24	24	24
Low Mountain	BLM	250	280	300	350	28	31	34	39
New Oraibi	BLM	600	840	1,100	1,800	67	94	123	201
Pinon	BLM	500	560	600	700	58	65	70	81
Polacca	BLM	500	560	600	700	56	63	67	78
Subtotal	BLM	3,040	3,580	4,090	5,340	334	395	453	591
Winslow	CDI	7,660	10,500	12,830	15,580	1,702	2,328	2,846	3,456
Subtotal	CDI	7,660	10,500	12,830	15,580	1,702	2,328	2,846	3,456
Heber	CHV	500	830	1,050	1,350	75	124	158	203
Overgaard	CHV	800	1,300	1,660	2,150	88	142	183	237
Subtotal	CHV	1,300	2,130	2,710	3,500	163	266	341	440

TABLE 4: PRESENT & PROJECTED POPULATION & M&I WATER WITHDRAWALS
LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO
(continued)

LOCATION	Water Use Area	POPULATION 1/ 1975	1990	2000	2020	WATER DEMANDS 1975 2/	1990 3/	2000 3/	2020 3/
						(acre-feet per year)			
Navajo Co., Arizona (Cont.)									
Holbrook	HOL	5,090	7,000	8,570	10,380	1,330	1,822	2,234	2,713
Joseph City	HOL	1,000	1,100	1,150	1,300	139	153	160	181
Woodruff	HOL	200	300	350	420	45	69	79	95
Subtotal	HOL	6,290	8,400	10,070	12,100	1,514	2,044	2,473	2,989
Shumway	SNO	200	650	750	900	22	71	82	99
Snowflake	SNO	2,570	4,260	5,310	6,490	474	782	976	1,194
Taylor	SNO	1,500	2,480	3,160	3,900	165	272	348	429
Subtotal	SNO	4,270	7,390	9,220	11,290	661	1,125	1,406	1,722
Pinetop/Lakeside	WHM	5,000	8,340	10,180	12,320	974	1,627	1,987	2,396
Show Low	WHM	3,380	5,580	6,930	8,440	503	831	1,032	1,257
Subtotal	WHM	8,380	13,920	17,110	20,760	1,477	2,458	3,019	3,653
TOTAL COUNTY		30,940	45,920	56,030	68,570	5,851	8,616	10,538	12,851
TOTAL ARIZONA		82,460	126,310	154,815	203,425	12,510	18,980	23,259	30,134
Catron Co., New Mexico									
Quemado	CAR	350	375	450	500	11	27	35	45
TOTAL COUNTY		350	375	450	500	11	27	35	45
McKinley Co., New Mexico									
Gallup	UPR	16,950	41,400	54,800	100,000	2,900	7,200	9,800	21,300
Gamerco	UPR	400	400	400	400	56	56	56	56
Zuni	ZUN	5,380	10,350	13,900	25,500	140	1,800	2,500	5,400
TOTAL COUNTY		22,730	52,150	69,100	125,900	3,096	9,056	12,356	26,756

TABLE 4: PRESENT & PROJECTED POPULATION & M&I WATER WITHDRAWALS
LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO
(continued)

LOCATION	Water Use Area	POPULATION 1/ 1975	1990	2000	2020	WATER DEMANDS 1975 2/ (acre-feet per year)	1990 3/	2000 3/	2020 3/
Valencia Co., New Mexico 4/		---	---	---	---	---	---	---	---
TOTAL NEW MEXICO		23,080	52,525	69,550	126,400	3,107	9,083	12,391	26,801
TOTAL BASIN		105,540	178,835	224,365	329,825	15,617	28,063	35,650	56,935

1/ ESS population estimate and projections developed in connection with river basin study.

2/ Data obtained from U.S. Geological Survey, Arizona Department of Health Services, Published Data and interviews with community officials.

3/ Calculated from percapita use rates and ESS population projections.

4/ Because of its rural nature, no population figures, thus, no water demands were developed for the communities located in Valencia County, New Mexico.

Rural Domestic and Livestock Water

For this study, rural domestic water is defined as all water used for domestic purposes by Basin residents residing outside the cities and towns specifically studied in the municipal and industrial water supply section of this report. The amount of water used for rural domestic and livestock purposes is small in comparison to that used for other purposes.

Most of the rural domestic water is obtained from pumped groundwater, although spring development is also used in some locations. In many rural areas, domestic water is scarce, if not nonexistent. In other areas, the depth to water or poor water quality may limit the availability of an adequate water supply. (See "Availability of Groundwater for Irrigation, Municipal and Industrial Use" in Appendix II.)

Water for livestock is also scarce in many areas. Flow on many of the drainage courses on which stock ponds have been constructed is infrequent and erratic. In order to provide carryover between streamflows, the tendency has been to construct ponds with large surface areas which increases the amount of water lost due to evaporation and seepage. The amount of water lost in the ordinary stock pond to evaporation and seepage is more than seven times that consumed by livestock. A site with a high depth to storage ratio is preferred, since the performance of a stock pond is more dependent upon its depth than upon its capacity.

In addition to stock ponds, water for livestock is obtained from wells, springs and live streams. Water harvesting, through artificial catchments, also supplies some water in certain locations. Associated facilities used to distribute the water include storage tanks, pipelines and watering troughs.

The projected conditions for rural domestic water supplies do not appear to be much different from those under present conditions, although a limited number of central water supply systems are being installed. Also, because of high cost of development, individual families generally are not able to develop their own supplies.

The future development of additional livestock water supplies is somewhat different. The possibility of increasing livestock water supplies has been improved with the introduction of artificial catchments and the increased use of wells, pipelines and water troughs. The continued and increased use of stock ponds is also a means of ensuring an adequate water supply for livestock. The ranchers in the southern half of Apache County still favor the stock pond as the ultimate source for stockwater.

Development of Surface Water Resources

USDA conducted reconnaissance level studies, primarily engineering and geologic, on the potential for future development of surface water within the Basin. These investigations did not include any sites in New Mexico nor on the Indian Reservations. There were, however, 210 sites with a storage capacity of 10 acre feet or greater that were inventoried by USDA; 175 in Arizona and 35 in New Mexico. The data presented for these sites includes the

location, stream or tributary, drainage area, structure type, uses, height, capacity, surface area, land status, irrigation water user, and a partial determination of improvements needed.

The new sites studied by USDA include 26 sites in Arizona that may have potential for future construction and 14 sites that USDA considers to be unfeasible. The 26 potentially feasible sites include 9 irrigation/recreation reservoirs, 13 single purpose recreation reservoirs, 1 site for possible utilization of intermittent storage in closed basins, and 3 single purpose sediment control sites. Although all the feasible sites offer potential, it may be that resources would most profitably be devoted to improving existing reservoirs rather than creating new ones.

Within the Basin, there were 35 other sites that have either been investigated or proposed over the last 50 years. Data was developed by USDA to summarize the status of these proposals for future reference. Included are 9 multi-purpose reservoirs investigated by the U.S. Bureau of Reclamation; 3 flood control sites investigated by the Corps of Engineers; 1 flood control and recreation reservoir currently under investigation by the Soil Conservation Service under Public Law 566 (Cottonwood Wash); 7 reservoir proposals under consideration by the Little Colorado River Plateau Resource Conservation and Development Area; 3 projects that would develop surface water supplies for M&I use for the City of Flagstaff; and other 12 sites classified as miscellaneous. Several of these latter sites represent old proposals that are considered unfeasible.

Although several sites appear to be feasible, there is very little opportunity to construct quality reservoirs in the Basin. Water is scarce and oversubscribed in some areas. Most of the good sites have been developed. Competition for a scarce natural resource generates conflicts between users, particularly when development has an unfavorable impact upon wildlife habitat or other aspects of the natural environment.

Several of the sites studied by USDA offer potential for additional irrigation storage, but the need for more irrigation storage is subject to question. Resources should first be spent on improving existing distribution systems and improved irrigation water management rather than construction of any new irrigation reservoirs.

Many existing recreation lakes appear to be under-utilized. Resources should perhaps be spent in the following areas rather than for new construction:

--More emphasis on urban lakes close to population centers. The attractiveness of remote sites will continue to diminish with increasing energy costs.

--Improve existing facilities, including improved access, water weed control, and boating and camping facilities.

--Inventory and publicize fishing opportunities. There are many lakes in the Basin that offer quality fishing that are unknown to the general public.

--Negotiate with irrigation water users on maintaining minimum pools for recreation and fish and wildlife instead of complete drawdown for irrigation purposes.

Surface Water Budgets (Including Pumped Groundwater)

Water budgets were developed for 18 selected water use areas (WUA's) in addition to that for the Total Basin. In Arizona, the WUA's (with minor modifications) are those defined by the Arizona Department of Water Resources and the U.S. Geological Survey in their study of groundwater resources for the state. In New Mexico, boundaries for the water use areas follow drainage divides based on boundaries of the Hydrologic Unit Map - 1974. (See Surface Water Budget Map-Including Pumped Groundwater - 1975.)

The water budgets are based on best estimates of water supply, water use, and outflow. These are given in both tabular (Table 5) and graphical forms (Water Budget Map) for the 1975 stage of water development, but only the tabular form (Tables 6, 7, and 8) was used to display the water budgets under future conditions. A summary of the total water supply, withdrawal and surface water outflow for present and projected periods is given in Table 9.

The budgets are not in the truest sense complete water budgets. This results from inadequate data to completely determine the relationships between surface water and groundwater flow regimes; therefore, net change in water storage (surface and groundwater) cannot be determined. The relationships between surface water and groundwater have been studied in only two locations within the Basin. These are in the southern portions of Navajo and Apache Counties in Arizona. A groundwater model was developed by the U.S. Geological Survey for the southern part of Navajo County in 1976 and one is presently under development for the southern part of Apache County.

The available water supply is defined as equal to the average annual runoff (including springflow) plus pumped groundwater. The average annual runoff is further divided into two categories - Net Surface Runoff and Surface Inflow. The Net Surface Runoff is the total runoff within an evaluation unit minus transmission losses such as channel losses, evaporation, evapotranspiration, etc. Surface Inflow is the surface water which enters an evaluation unit from an adjoining WUA (see Surface Water Budget Map).

The term "water use" is defined in the broad sense, and includes all natural and man-controlled demands placed upon the stated water supply. Water use may be further defined with reference to "withdrawal" or "depletion" requirements. "Withdrawal requirement" is defined as the total quantity of water required at the point of diversion to satisfy a given need. "Depletion requirement" is defined as the amount of water removed by a use from the water supply cycle. Due to the lack of data to adequately determine the depletion requirements, and since the total relationship between surface water and groundwater is unknown, withdrawal requirements were used in the water budget analyses. The total amount of water withdrawn for a purpose, therefore, is charged to that purpose.

TABLE 5: AVERAGE ANNUAL WATER BUDGETS - 1975 1/

LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO

WATER USE AREA	WATER SUPPLY (AC-FT)				WATER USE (AC-FT)								
	PUMPED GROUND-WATER	NET SURFACE RUNOFF	SURFACE INFLOW	TOTAL SUPPLY	IRRIGATION AND LIVESTOCK	M&I & RURAL DOMESTIC	MAJOR INDUSTRIAL	STEAM ELECTRIC	FISH & WILDLIFE	RECREATION	CHANNEL LOSS	TOTAL WITHDRAWAL	SURFACE OUTFLOW 2/
	(AC-FT)	(AC-FT)	(AC-FT)	(AC -FT)	(AC-FT)	(AC-FT)	(AC-FT)	(AC-FT)	(AC-FT)	(AC-FT)	(AC-FT)	(AC-FT)	(AC-FT)
ARIZONA													
(BLM) Black Mesa	5,050	22,800		27,850	2,250	900	4,100		150			7,400	20,450
(BOD) Bodaway Mesa	50	83,550	56,550	140,150	200	50			200			450	139,700
(CDI) Canyon Diablo	2,750	13,400	135,800	151,950	9,750	1,700			3,750	5,850	6,400	27,450	124,500
(CHV) Chevelon	200	115,650	37,850	153,700	1,900	200	3,050		1,850	1,200	3,200	11,400	142,300 3/
(CHN) Chinle	1,450	15,250	4,200	20,900	4,400	1,400			100	50		5,950	14,950
(CON) Concho	7,850	3,800	17,700	29,350	15,300	100		50 4/	750			16,200	13,150
(HOL) Holbrook	16,600	9,000	74,250	99,850	14,000	1,550		3,300	2,000		4,700	25,550	74,300
(HOP) Hopi	550	15,450	67,200	83,200	2,200	500			1,800		18,650	23,150	60,050
(KAI) Kaibito Plateau	100	1,650		1,750	300	100						400	1,350
(PRZ) Puerco-Zuni	1,950	27,750	27,150	56,850	3,300	150			1,300			4,750	52,100
(SFP) San Francisco Peaks	2,300	102,200	123,800	228,300	1,800	5,550			450	200	9,000	17,000	211,300
(STJ) St. Johns	1,200	6,650	28,550	36,400	27,200	250		200	300	500		28,450	7,950
(SNO) Snowflake	29,300	14,550	10,600	54,450	23,600	700	15,750		250	1,550		41,850	12,600
(TUB) Tuba City	950	250	10,650	11,850	900	950			200			2,050	9,800
(WHM) White Mountains	2,250	70,100		72,350	29,200	1,950	450		1,250	800		33,650	38,700 5/
TOTAL ARIZONA	72,550	502,050	30,900 6/	605,500 7/	136,300	16,050	23,350	3,550	14,350	10,150	41,950	245,700	359,800 10/
NEW MEXICO													
(CAR) Carrizo Wash	100	7,600		7,700	800	50			450			1,300	6,400
(UPR) Upper Puerco	5,000	20,550		25,550	2,150	4,250	700		500	50		7,650	17,900
(ZUN) Zuni	1,500	19,450		20,950	12,200	200	1,150		150	650		14,350	6,600
TOTAL NEX MEXICO	6,600	47,600		54,200 8/	15,150	4,500	1,850		1,100	700		23,300	30,900 6/
TOTAL BASIN	79,150	549,650		628,800 9/	151,450	20,550	25,200	3,550	15,450	10,850	41,950	269,000	359,800 10/

1/ Includes pumped groundwater.
2/ Surface Outflow equals Total Supply minus Total Withdrawal.
3/ Includes 10,900 acre-feet pumped from Blue Ridge Reservoir and exported to the East Verde River in the Salt River Basin.
4/ This water is exported to the STJ Water Use Area for use by the Coronado Steam Electric Power Plant near St. Johns.
5/ Includes 3,300 acre-feet pumped from Show Low Lake and exported to Forestdale Creek in the Salt River Basin.
6/ Estimated surface water inflow to Arizona (and/or outflow from New Mexico) portion of Basin. (see Water Budget map).
7/ 8/ 9/ These figures represent the total water supply for Arizona, New Mexico, and Total Basin, respectively, and are the sum of net surface runoff plus pumped groundwater. For the Arizona portion of the Basin it also includes the inflow from New Mexico, (see footnote 6).
10/ Estimated outflow from the Basin including the flow at the Basin's outlet plus 14,200 acre-feet exported from the Basin as noted in footnotes 3 & 5.

TABLE 6: AVERAGE ANNUAL WATER BUDGETS - 1990 1/

LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO

WATER USE AREA	WATER SUPPLY (AC-FT) PUMPED GROUND-WATER (AC-FT)	NET SURFACE RUNOFF (AC-FT)	SURFACE INFLOW (AC-FT)	TOTAL SUPPLY (AC-FT)	WATER USE (AC-FT) IRRIGATION AND LIVESTOCK (AC-FT)	M&I & RURAL DOMESTIC (AC-FT)	MAJOR INDUSTRIAL (AC-FT)	STEAM ELECTRIC (AC-FT)	FISH & WILDLIFE (AC-FT)	RECREATION (AC-FT)	CHANNEL LOSS (AC-FT)	TOTAL WITHDRAWAL (AC-FT)	SURFACE OUTFLOW 2/ (AC-FT)
ARIZONA													
(BLM) Black Mesa	5,550	22,800		28,350	2,250	1,400	4,100		150			7,900	20,450
(BOD) Bodaway Mesa	100	83,550	52,000	135,650	200	100			200			500	135,150
(CDI) Canyon Diablo	3,400	13,400	131,900	148,700	9,750	2,350			3,750	5,850	6,400	28,100	120,600
(CHV) Chevelon	300	115,650	34,050	150,000	1,900	300	3,050		1,850	1,300	3,200	11,600	138,400 3/
(CHN) Chinle	1,900	15,250	3,500	20,650	4,400	1,850			100	750		7,100	13,550
(CON) Concho	12,750	3,800	13,500	30,050	15,300	150		4,900 4/	750			21,100	8,950
(HOL) Holbrook	27,400	9,000	67,150	103,550	14,000	2,150		13,500	2,000	550	4,700	36,900	66,650
(HOP) Hopi	900	15,450	62,650	79,000	2,200	850			1,800		18,650	23,500	55,500
(KAI) Kaibito Plateau	200	1,650		1,850	300	200						500	1,350
(PRZ) Puerco-Zuni	2,100	27,750	20,050	49,900	3,300	300			1,300			4,900	45,000
(SFP) San Francisco Peaks	4,650	102,200	119,900	226,750	1,800	7,900			450	200	9,000	19,350	207,400
(STJ) St. Johns	21,950	6,650	28,550	57,150	27,200	600		20,600	300	500		49,200	7,950
(SNO) Snowflake	29,800	14,550	10,600	54,950	23,600	1,200	15,750		250	1,550		42,350	12,600
(TUB) Tuba City	1,500	250	10,650	12,400	900	1,500			200			2,600	9,800
(WHM) White Mountains	3,500	70,100		73,600	29,200	3,200	450		1,250	800		34,900	38,700 5/
TOTAL ARIZONA	116,000	502,050	23,800 6/	641,850 7/	136,300	24,050	23,350	39,000	14,350	11,500	41,950	290,500	351,350 10/
NEW MEXICO													
(CAR) Carrizo Wash	1,000	7,600		8,600	750	50	950		450			2,200	6,400
(UPR) Upper Puerco	10,250	20,550		30,800	2,050	8,200	2,500		3,000	50		15,800	15,000
(ZUN) Zuni	12,800	19,450		32,250	23,950	1,850	1,650		1,750	650		29,850	2,400
TOTAL NEX MEXICO	24,050	47,600		71,650 8/	26,750	10,100	5,100		5,200	700		47,850	23,800 6/
TOTAL BASIN	140,050	549,650		689,700 9/	163,050	34,150	28,450	39,000	19,550	12,200	41,950	338,350	351,350 10/

1/ Includes pumped groundwater.
2/ Surface Outflow equals Total Supply minus Total Withdrawal.
3/ Includes 10,900 acre-feet pumped from Blue Ridge Reservoir and exported to the East Verde River in the Salt River Basin.
4/ This water is exported to the STJ Water Use Area for use by the Coronado Steam Electric Power Plant near St. Johns.
5/ Includes 3,300 acre-feet pumped from Show Low Lake and exported to Forestdale Creek in the Salt River Basin.
6/ Estimated surface water inflow to Arizona (and/or outflow from New Mexico) portion of Basin.
7/ 8/ 9/ These figures represent the total water supply for Arizona, New Mexico, and Total Basin, respectively, and are the sum of net surface runoff plus pumped groundwater. For the Arizona portion of the Basin it also includes the inflow from New Mexico, (see footnote 6).
10/ Estimated outflow from the Basin including the flow at the Basin's outlet plus 14,200 acre-feet exported from the Basin as noted in foo-notes 3 & 5.

TABLE 7: AVERAGE ANNUAL WATER BUDGETS - 2000 1/

LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO

WATER USE AREA	WATER SUPPLY (AC-FT)				WATER USE (AC-FT)								
	PUMPED GROUND-WATER (AC-FT)	NET SURFACE RUNOFF (AC-FT)	SURFACE INFLOW (AC-FT)	TOTAL SUPPLY (AC-FT)	IRRIGATION AND LIVESTOCK (AC-FT)	M&I & RURAL DOMESTIC (AC-FT)	MAJOR INDUSTRIAL (AC-FT)	STEAM ELECTRIC (AC-FT)	FISH & WILDLIFE (AC-FT)	RECREATION (AC-FT)	CHANNEL LOSS (AC-FT)	TOTAL WITHDRAWAL (AC-FT)	SURFACE 2/ OUTFLOW (AC-FT)
ARIZONA													
(BLM) Black Mesa	5,900	22,800		28,700	2,250	1,750	4,100		150			8,250	20,450
(BOD) Bodaway Mesa	150	83,550	51,050	134,750	200	150			200			550	134,200
(CDI) Canyon Diablo	3,950	13,400	130,950	148,300	9,750	2,900			3,750	5,850	6,400	28,650	119,650
(CHV) Chevelon	400	115,650	33,100	149,150	1,900	400	3,050		1,850	1,300	3,200	11,700	137,450 3/
(CHN) Chinle	2,350	15,250	3,000	20,600	4,400	2,300			100	750		7,550	13,050
(CON) Concho	12,750	3,800	13,600	30,150	15,300	150		4,900 4/	750			21,100	9,050
(HOL) Holbrook	27,850	9,000	65,250	102,100	14,000	2,600		13,500	2,000	550	4,700	37,350	64,750
(HOP) Hopi	1,200	15,450	61,700	78,350	2,200	1,150			1,800		18,650	23,800	54,550
(KAI) Kaibito Plateau	300	1,650		1,950	300	300						600	1,350
(PRZ) Puerco-Zuni	2,150	27,750	18,150	48,050	3,300	350			1,300			4,950	43,100
(SFP) San Francisco Peaks	6,150	102,200	118,950	227,300	1,800	9,400			450	200	9,000	20,850	206,450
(STJ) St. Johns	27,450	6,650	28,650	62,750	27,200	700		26,000	300	500		54,700	8,050
(SNO) Snowflake	30,150	14,550	10,600	55,300	23,600	1,550	15,750		250	1,550		42,700	12,600
(TUB) Tuba City	1,900	250	10,650	12,800	900	1,900			200			3,000	9,800
(WHM) White Mountains	4,350	70,100		74,450	29,200	4,050	450		1,250	800		35,750	38,700 5/
TOTAL ARIZONA	127,000	502,050	21,900 6/	650,950 7/	136,300 10/	29,650	23,350	44,400	14,350	11,500	41,950	301,500	349,450 11/
NEW MEXICO													
(CAR) Carrizo Wash	1,650	7,600		9,250	700	50	1,550		450			2,750	6,500
(UPR) Upper Puerco	4,650	20,550	7,500 12/	32,700	1,300	10,850	2,900		4,600	50		19,700	13,000
(ZUN) Zuni	17,150	19,450		36,600	23,500	2,550	1,950	2,300	3,250	650		34,200	2,400
TOTAL NEX MEXICO	23,450	47,600	7,500 12/	78,550 8/	25,500	13,450	6,400	2,300	8,300	700		56,650	21,900 6/
TOTAL BASIN	.150,450	549,650	7,500 12/	707,600 9/	161,800	43,100	29,750	46,700	22,650	12,200	41,950	358,150	349,450 11/

1/ Includes pumped groundwater.
2/ Surface Outflow equals Total Supply minus Total Withdrawal.
3/ Includes 10,900 acre-feet pumped from Blue Ridge Reservoir and exported to the East Verde River in the Salt River Basin.
4/ This water is exported to the STJ Water Use Area for use by the Coronado Steam Electric Power Plant near St. Johns.
5/ Includes 3,300 acre-feet pumped from Show Low Lake and exported to Forestdale Creek in the Salt River Basin.
6/ Estimated surface water inflow to Arizona (and/or outflow from New Mexico) portion of Basin.
7/ 8/ 9/ These figures represent the total water supply for Arizona, New Mexico, and Total Basin, respectively, and are the sum of net surface runoff plus pumped groundwater. For the Arizona portion of the Basin it also includes the inflow from New Mexico (see footnote 6), and in New Mexico 7,500 acre-feet are imported from San Juan Basin. (see footnote 12).
10/ Although Table 1-4, Appendix II, Section 1, Irrigation shows a potential reduction in withdrawals for irrigation in Arizona (due to increased efficiencies in projected periods 2000 and 2020); it was assumed in the water budget analysis that the total withdrawals for this purpose would remain the same, and that any water saved would be used to increase crop yields or to irrigate native grasses.
11/ Estimated outflow from the Basin including the flow at the Basin's outlet plus 14,200 acre-feet exported from the Basin as noted in footnotes 3 & 5.
12/ Surface water imported from the San Juan River Basin for use in Gallup, Nes Mexico.

TABLE 8: AVERAGE ANNUAL WATER BUDGETS - 2020 1/

LITTLE COLORADO RIVER BASIN, ARIZONA AND NEW MEXICO

WATER USE AREA	WATER SUPPLY (AC-FT) PUMPED GROUND-WATER (AC-FT)	NET SURFACE RUNOFF (AC-FT)	SURFACE INFLOW (AC-FT)	TOTAL SUPPLY (AC-FT)	WATER USE (AC-FT) IRRIGATION AND LIVESTOCK (AC-FT)	M&I & RURAL DOMESTIC (AC-FT)	MAJOR INDUSTRIAL (AC-FT)	STEAM ELECTRIC (AC-FT)	FISH & WILDLIFE (AC-FT)	RECREATION (AC -FT)	CHANNEL LOSS (AC-FT)	TOTAL WITHDRAWAL (AC-FT)	SURFACE OUTFLOW 2/ (AC-FT)
ARIZONA													
(BLM) Black Mesa	6,600	22,800		29,400	2,250	2,450	4,100		150			8,950	20,450
(BOO) Bodaway Mesa	200	83,550	51,050	134,800	200	200			200			600	134,200
(COI) Canyon Diablo	4,550	13,400	130,950	148,900	9,750	3,500			3,750	5,850	6,400	29,250	119,650
(CHV) Chevelon	500	115,650	33,100	149,250	1,900	500	3,050		1,850	1,300	3,200	11,800	137,450 3/
(CHN) Chinle	3,300	15,250	3,000	21,550	4,400	3,250			100	750		8,500	13,050
(CON) Concho	12,800	3,800	13,700	30,300	15,300	200		4,900 4/	750			21,150	9,150
(HOL) Holbrook	28,400	9,000	65,250	102,650	14,000	3,150		13,500	2,000	550	4,700	37,900	64,750
(HOP) Hopi	1,650	15,450	61,700	78,800	2,200	1,600			1,800		18,650	24,250	54,550
(KAI) Kaibito Plateau	400	1,650		2,050	300	400						700	1,350
(PRZ) Puerco-Zuni	2,200	27,750	18,150	48,100	3,300	400			1,300			5,000	43,100
(SFP) San Francisco Peaks	7,650	102,200	118,950	228,800	1,800	10,900			450	200	9,000	22,350	206,450
(STJ) St. Johns	27,600	6,650	28,750	63,000	27,200	850		26,000	300	500		54,850	8,150
(SNO) Snowflake	30,500	14,550	10,600	55,650	23,600	1,900	15,750		250	1,550		43,050	12,600
(TUB) Tuba City	2,500	250	10,650	13,400	900	2,500			200			3,600	9,800
(WHM) White Mountains	5,200	70,100		75,300	29,200	4,900	450		1,250	800		36,600	38,700 5/
TOTAL ARIZONA	134,050	502,050	21,900 6/	658,000 7/	136,300 10/	36,700	23,350	44,400	14,350	11,500	41,950	308,550	349,450 11/
NEW MEXICO													
(CAR) Carrizo Wash	5,550	7,600		13,150	650	50	5,400		450			6,550	6,600
(UPR) Upper Puerco	17,100	20,550	7,500 12/	45,150	1,250	22,550	3,800		4,600	50		32,250	12,900
(ZUN) Zuni	24,250	19,450		43,700	21,650	5,650	3,700	6,400	3,250	650		41,300	2,400
TOTAL NEX MEXICO	46,900	47,600	7,500 12/	102,000 8/	23,550	28,250	12,900	6,400	8,300	700		80,100	21,900 6/
TOTAL BASIN	180,950	549,650	7,500 12/	738,100 9/	159,850	64,950	36,250	50,800	22,650	12,200	41,950	388,650	349,450 11/

1/ Includes pumped groundwater.
2/ Surface Outflow equals Total Supply minus Total Withdrawals.
3/ Includes 10,900 acre-feet pumped from Blue Ridge Reservoir and exported to the East Verde River in the Salt River Basin.
4/ This water is exported to the STJ Water Use Area for use by the Coronado Steam Electric Power Plant near St. Johns.
5/ Includes 3,300 acre-feet pumped from Show Low Lake and exported to Forestdale Creek in the Salt River Basin.
6/ Estimated surface water inflow to Arizona (and/or outflow from New Mexico) portion of Basin.
7/ 8/ 9/ These figures represent the total water supply for Arizona, New Mexico, and Total Basin, respectively, and are the sum of net surface runoff plus pumped groundwater. For the Arizona portion of the Basin it also includes the inflow from New Mexico (see footnote 6), and in New Mexico 7,500 acre-feet are imported from San Juan Basin. (see footnote 12.)

10/ Although Table 1-4, Appendix II, Section 1, Irrigation shows a potential reduction in withdrawals for irrigation in Arizona (due to increased efficiencies in projected periods 2000 and 2020); it was assumed in the water budget analysis that the total withdrawals for this purpose would remain the same, and that any water saved would be used to increase crop yields or to irrigate native grasses.
11/ Estimated outflow from the Basin including the flow at the Basin's outlet plus 14,200 acre-feet exported from the Basin as noted in footnotes 3 & 5.
12/ Surface water imported from the San Juan River Basin for use in Gallup, New Mexico.

TABLE 9 - Summary of Water Supply, Withdrawl and Surface Outflow
Little Colorado River Basin, Arizona and New Mexico

	1975			1990			2000			2020		
	Arizona	New Mexico	Total	Arizona	New Mexico	Total	Arizona	New Mexico	Total	Arizona	New Mexico	Total
WATER SUPPLY												
Pumped Groundwater	72,550	6,600	79,150	116,000	24,050	140,050	127,000	23,450	150,450	134,050	46,900	180,950
Net Surface Runoff	502,050	47,600	549,650	502,050	47,600	549,650	502,050	47,600	549,650	502,050	55,100 1/	557,150 1/
Total	574,600	54,200	628,800	618,050	71,650	689,700	629,100	71,050	700,150	636,100	102,000	738,100
WATER WITHDRAWL												
Irrigation & Livestock	136,300	15,150	151,450	136,300	26,750	163,050	136,300	25,500	161,800	136,300	23,550	159,850
M&I and Rural Domestic	16,050	4,500	20,550	24,050	10,100	34,150	29,650	13,450	43,100	36,700	28,250	64,950
Major Industry	23,350	1,850	25,200	23,350	5,100	28,450	23,350	6,400	29,750	23,350	12,900	36,250
Steam Electric	3,550	0	3,550	39,000	0	39,000	44,400	2,300	46,700	44,400	6,400	50,800
Fish & Wildlife	14,350	1,100	15,450	14,350	5,200	19,550	14,350	8,300	22,650	14,350	8,300	22,650
Recreation	10,150	700	10,850	11,500	700	12,200	11,590	700	12,200	11,500	700	12,200
Channel Loss	41,950	0	41,950	41,950	0	41,950	41,950	0	41,950	41,950	0	41,950
Total	245,700	23,300	269,000	290,500	47,850	338,350	301,500	56,650	358,150	308,550	80,100	388,650
SURFACE OUTFLOW 2/	328,900	30,900	359,800	327,550	23,800	351,350	327,600	14,400	342,000	327,550	21,900	349,450

1/ Includes 7,500 AC-FT import from San Juan River Basin for use in Gallup, New Mexico.
2/ Surface Outflow equals Total Water Supply minus Total Water Withdrawl.

Surface water outflow is the streamflow leaving a WUA. These are the most reliable values in the water budget tables, since they represent long term records of streamflow measurements made at several locations. With the stated definitions, water supply, use, and surface outflows are shown in the water budget tables (Tables 5, 6, 7, and 8). Other basic assumptions or definitions made with reference to the water budgets are defined in Appendix II.

EROSION AND SEDIMENT, AND FLOODING 1/

Erosion and Sediment

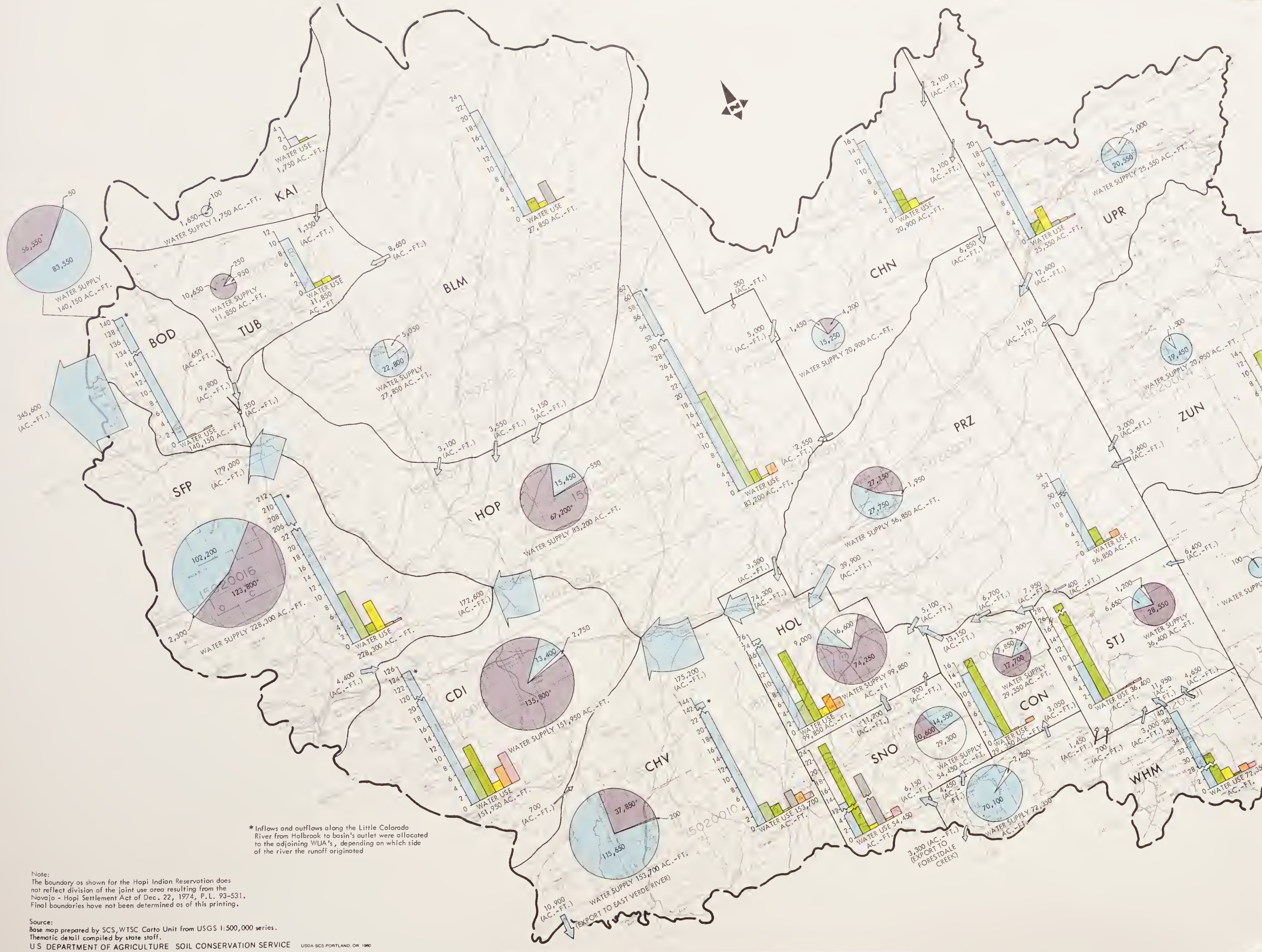
Sheet and rill erosion accounts for the larger amount of erosion in the Basin. Most of the sloping lands are experiencing some sheet and rill erosion. Areas with good grass cover and forested areas have relatively low rates of erosion. The highest rates occur in areas of badland topography. Severe erosion is occurring in some alluvial valleys and on the valley slopes of the Little Colorado, Puerco, and Zuni Rivers. About 5,300 miles of channel banks are experiencing moderate to severe erosion. Sheet and rill erosion rates vary from less than 0.6 tons per acre to over 9 tons per acre per year. (See Erosion Classification Map, Appendix III.) The total erosion is about 32.4 million tons per year.

About 10.2 million tons, or 32 percent of the total sediment produced in the Basin, is transported to the Colorado River. Erosion processes within the Basin adds about 72,000 tons of salt annually to the Colorado River; however, the major contributor of salts from the Basin is Blue Springs and other springs located near the mouth of the Little Colorado River, which contributes about 550,000 tons of salt per year.

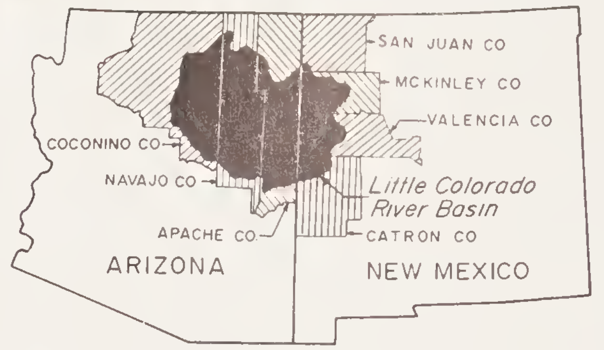
USDA proposes two alternative resource improvement plans to reduce soil erosion, protect water quality and improve productivity, wildlife habitat and esthetics. One plan emphasizes national economic development (NED) and the other plan emphasizes environmental quality (EQ). A recommended plan was not developed. Planned elements for the two alternatives are shown in Tables 10 and 11 which follow. The general approaches in the two plans are very similar. The major difference is that in the EQ Plan maintenance and improvement of wildlife habitat and esthetics are emphasized. For example in the EQ Plan, 60 percent of the annual growth is left compared to only 50 percent in the NED Plan as recommended for safe grazing. Other elements in the EQ alternative include the use of smooth wire on the bottom of barbed wire fences to allow wildlife freedom to roam; creating wildlife habitat around ponds; providing a variety of seed for better food and cover for wildlife when applying the range seeding practice; leaving strips of brush for wildlife when vegetation is removed; and fencing portions of the stock water developments and wetlands for wildlife.

The total impact of either alternative on the salts and sediment delivered to the Colorado River is very similar. If either or a combination of the plans is installed, the total salts delivered to the river will be reduced by 1.4

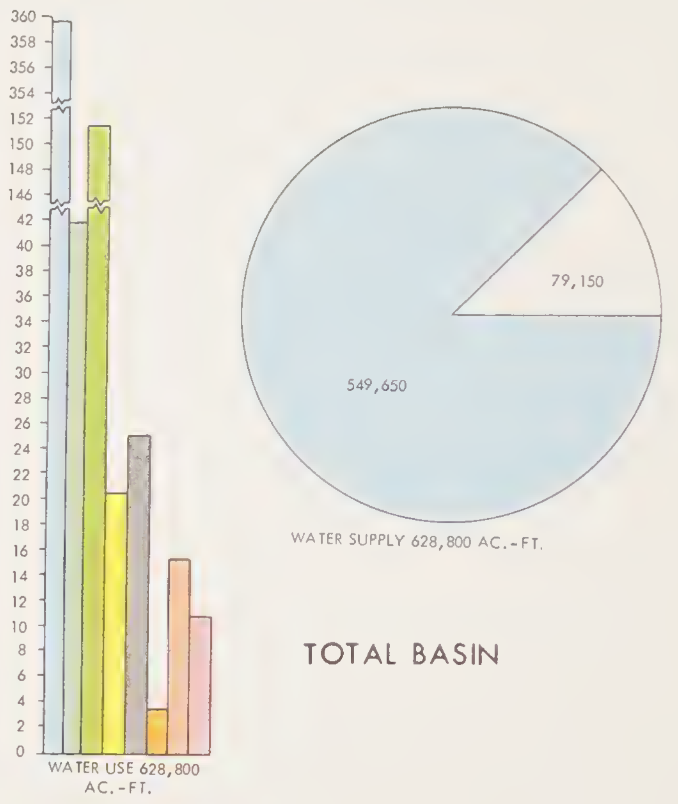
1/ See Appendix III for detailed data.



* Inflows and outflows along the Little Colorado River from Holbrook to basin's outlet were allocated to the adjoining WUA's, depending on which side of the river the runoff originated

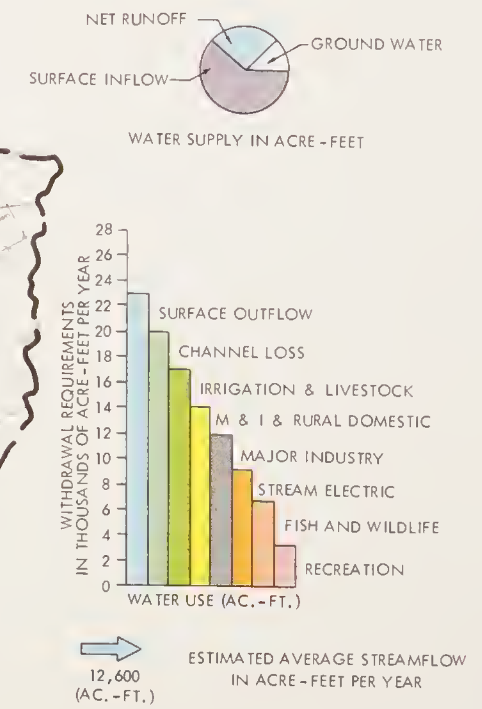


LOCATION MAP



TOTAL BASIN

EXPLANATION



WATER USE AREAS

Arizona

- BLM Black Mesa Area
- BOD Badaway Mesa Area
- CDI Canyon Diablo Area
- CHV Chevelan Area
- CHN Chinle Valley Area
- CON Concho Area
- HOL Halbrook Area
- HOP Hapi Area
- KAI Kaibita Plateau Area
- PRZ Puerca - Zuni Area
- STJ St. Johns Area
- SFP San Francisca Peaks Area
- SNO Snowflake Area
- TUB Tuba City Area
- WHM White Mountain Area

New Mexica

- CAR Carriza Wash Area
- UPR Upper Puerco Area
- ZUN Zuni Area

NOTE:
In Arizona, Water Use Areas are Ground Water Study Areas; In New Mexico they represent Hydrologic Boundaries.

15020004 Hydrologic Unit Code, U.S. Water Resources Council

SURFACE WATER BUDGET
(INCLUDING PUMPED GROUNDWATER)
1975 CONDITION
LITTLE COLORADO RIVER BASIN
ARIZONA AND NEW MEXICO

JULY 1980

10 0 10 20 MILES
SCALE 1:1,000,000

Note:
The boundary as shown for the Hopi Indian Reservation does not reflect division of the joint use area resulting from the Navajo - Hopi Settlement Act of Dec. 22, 1974, P.L. 93-531. Final boundaries have not been determined as of this printing.

Source:
Base map prepared by SCS, WTSC Carto Unit from USGS 1:500,000 series.
Thematic detail compiled by state staff.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA-SCS-PORTLAND, OR 1980

M7-EN-23833-17

TABLE 10: ELEMENTS OF THE RANGELAND RESOURCE MANAGEMENT SYSTEM - NED PLAN A

ITEM	UNITS	AMOUNT
Proper Grazing Use	Acres	7,896,000
Deferred Grazing	Acres	4,264,000
Planned Grazing System	Acres	7,896,000
Fence	Miles	3,000
Water Spreading	Acres	224,000
Brush Management	Acres	3,043,000
Range Seeding	Acres	894,000
Prescribed Burning	Acres	587,000
Mechanical Treatment	Acres	633,000
Stock Water Development	Number	4,000

TABLE 11: ELEMENTS OF THE RANGELAND RESOURCE MANAGEMENT SYSTEM - EQ PLAN B

ITEM	UNITS	AMOUNT
Proper Grazing Use	Acres	7,896,000
Deferred Grazing	Acres	4,264,000
Planned Grazing System (Livestock use restricted to 40 percent of annual forage growth. Wildlife taken into consideration as land users)	Acres	7,896,000
Fence 1/ (Bottom wire to be smooth in deference to antelope habits)	Miles	3,000
Water Spreading (Seed forbs and grasses upslope)	Acres	224,000
Brush Management (Emphasis on maximum wildlife habitat development and enhancement)	Acres	3,043,000
Range Seeding (Includes forbs, shrubs and special category species)	Acres	894,000
Prescribed Burning	Acres	587,000
Mechanical Treatment	Acres	633,000
Stock Water Development 2/	Number	4,000
Restricted area for wildlife (fenced)	Acres	25,000
Wetland improvement (fenced)	Acres	1,900

1/ Does not include 1671 miles of stock pond fencing.

2/ Assumes 2 to 1 development of ponds vs. wells, springs, etc.

percent or 9,000 tons per year, and sediment will be reduced by 3.95 million tons per year or about 38.7 percent.

Flooding

USDA investigated the potential for project actions that could be taken to solve significant flood problems in the Basin under the Watershed Protection and Flood Prevention Act (Public Law 566), and Resource Conservation and Development (RC&D) Program. Flooding along the main stem of the Little Colorado River and other areas that have a drainage area in excess of 250,000 acres were not studied, but studies by other agencies on these streams have been included in the discussions.

There are two watershed areas within the Basin that have been investigated and have potential for development under the Watershed Protection and Flood Prevention Act (PL-566); the Zuni Pueblo Watershed in New Mexico and the Cottonwood Wash Watershed in Arizona. The Zuni Pueblo Project has been authorized for construction, and the Cottonwood Wash Watershed is being planned.

No other area proved to be feasible under project-type action using USDA authorities. In all cases, the costs of significantly reducing or eliminating the flood problems exceeded the monetary benefits that would occur. Hence, the planning process did not proceed to the development of NED, EQ or Recommended Plans.

Although no project-type action under the USDA authorities could be justified, flood problems do exist in the Basin, and there are measures which could prove to be beneficial in selected areas. These include: flood plain zoning for appropriate use of flood plains, flood proofing to reduce damages on existing properties, flood insurance to reduce the monetary cost of flooding to individuals, relocation of urban properties out of the flood plain, tax incentives for not developing flood plain areas, flood forecasting, flood warning systems, emergency protection, post-flood recovery assistance, and adopting strict development regulations and building codes.

Flood plain areas along Silver Creek, the Little Colorado River, and Water Canyon in Arizona, and the Puerco River and tributaries, the Zuni River, Rio Pescado and Rio Nutria Washes in New Mexico, that have not been developed for urban uses, need controls to prevent unwise flood plain development. This need is particularly pronounced in St. Johns, Arizona, and in Gallup and Zuni Pueblo, New Mexico.

The U.S. Army Corps of Engineers has completed two flood control measures within the Basin; the Holbrook levee (1948) on the Little Colorado River at Holbrook and Ruby Wash Diversion (1970) at Winslow. A second measure at Winslow, the Ice House Wash Channel Improvement, is authorized and federally funded. However, the local administration found a more desirable alternative solution which was designed and installed by the Arizona Department of Transportation in conjunction with the drainage work for Interstate Highway 40.

The Corps has completed several other flood studies and flood plain information reports in the study area. These include flood plain information reports on Rio de Flag and Sinclair Washes in Flagstaff and on the Little Colorado River at Winslow.

The Corps has also performed emergency repair work under Public Law 84-99 on the Little Colorado River at Holbrook (1971, 1972), the Little Colorado River at Winslow (1971, 1972), and Daggs Dam on Silver Creek (1973).

Many similar type of studies and reports have been completed by the Corps in New Mexico, especially in the vicinity of Gallup.

The Bureau of Reclamation has conducted studies in the New Mexico portion of the Basin. These include studies with reference to dam safety on eight dams located on the Zuni Indian Reservation. In 1972, the Corps of Engineers completed a special flood hazard report for the Zuni Pueblo, which presented information on the flood hazard along the Zuni River.

The Corps has an authorized but unfunded study of flood problems on the Navajo Indian Reservation. This study is to provide information on flood control and related problems on the Reservation. Recently, Morrison Maierle, Inc., of Helena, Montana, a consulting engineering firm, completed a study which identified the flood prone areas on the Navajo Reservation. This study was performed under contract with the Bureau of Indian Affairs.

There have been numerous efforts by local interests to control damaging floods within the Little Colorado River Basin. Farmers and other individual property owners have constructed diversion dikes, water spreaders, channel improvements, etc., at many locations throughout the Basin to protect their properties.

Municipalities and counties have also been active in flood control work through the construction of dikes, channel improvements and debris removal; however, most of their efforts have been ineffective against large runoff events. Other attempts to control flood damages in the Basin include flood warning and forecasting systems, flood insurance studies, flood plain zoning, etc.

RECREATION, FISH AND WILDLIFE, AND TIMBER[1/]

Recreation

The climate, scenic attractions and proximity to major metropolitan areas make the Basin an important recreational resource for weekend and vacation use by residents of Phoenix, Tucson and Albuquerque. It also provides excellent vacation opportunities for other residents of Arizona and New Mexico and for tourists from other parts of the continental United States, Mexico and Canada. The major recreation attractions include the Petrified Forest National Park, El Morro, Walnut Canyon, Sunset Crater and Wupatki National Monuments, Lyman Lake State Park, and national forest recreation sites at Quemado Lake, Greer,

1/ See Appendix IV for detailed data.

Lakeside, Woods Canyon, Ashurst Lake and Willow Springs Lake. Water related activities, including camping near water, create the most demand for activity occasions.

Recreation opportunities for all seasons are available. During the winter months, the Arizona Snow Bowl near Flagstaff provides good alpine skiing. Cross-country skiing and snowmobiling are available in the Big Cienega, Mormon Lake, Greer and other areas along the Mogollon Rim. Fishing and turkey hunting are popular spring activities. The heaviest recreation use occurs during the summer months when the high plateau and forested areas provide climatic relief for residents of southern Arizona and tourists from other states. Camping, picnicking, fishing, nature study and hiking are the most popular activities.

There are many areas that have a high potential for recreation use; but due to an inadequate road system, are not readily accessible to the general public. Also, due to the remoteness of some of the areas, there is only limited knowledge of their existence. Overcrowding is a problem on some of the more readily accessible areas.

The Forest Service, through its Road and Trail Development Program, is continually opening new areas and providing improved access to some desirable areas. It is believed that with continuation of this and other Forest Service programs, access problems in the future will be greatly reduced.

The Forest Service also has an extensive public information program that can disseminate information about recreational opportunities that exist on national forests. Historically, this program has been very successful in informing the public about developed recreation areas. However, many recreational opportunities still exist on the national forests that are not generally known to the public. It is proposed that the Forest Service intensify its public information efforts to continually inform the public of the many recreational activities that are available.

Overcrowding of recreational areas is expected to continue in the future. Tables 12 and 12A show the existing and projected supply, demand and current needs in activity occasions for the concerned counties in Arizona and New Mexico. The projected supply figures represent those conditions that are expected to exist in the future if no new water resource or recreation projects or programs other than those authorized and funded are implemented. At the time of this writing, there were no new projects that met this criteria.

A total of nine projects, however, were selected for investigation as a part of this study. These nine sites were selected because of historical or present local interest in development. They are believed to be representative of the broad range of opportunities that exist in the Basin. Four of these, Hopi Water Based Recreation, Hidden Lake, Trout Lake, and Rio de Flag, were reviewed on a reconnaissance basis and were not investigated further. Hidden Lake, Trout Lake and the Hopi Water Based Recreation were deleted from more detailed study due to expected high development costs associated with construction or reconstruction of needed dams, small size (10-20 acres) of the recreation pools, and remoteness of their locations. A preliminary investigation

TABLE 12 - Existing and Projected Supply, Demand, and Unmet Recreation Demand, Future Without Plan Conditions In Activity Occasions, Little Colorado River Basin

Arizona Three County Area 1/

	Base Year - 1975			Projected - 1990			Projected - 2000			Projected - 2020		
Activity	Supply	Demand	Unmet Demand	Supply	Demand	Unmet Demand	Supply	Demand	Unmet Demand	Supply	Demand	Unmet Demand
Fishing	866,100	949,400	83,300	887,400	1,418,000	530,600	887,400	1,730,600	843,200	887,400	2,407,000	1,519,600
Picnicking	719,100	794,600	75,500	744,100	1,186,500	442,400	760,800	1,448,000	687,200	802,400	2,009,000	1,206,600
River and Lake Swimming	394,900	339,900	0	394,900	507,500	112,600	394,900	619,400	224,500	394,900	859,700	464,800
Camping - No Facilities	805,900	693,600	0	978,300	1,035,800	57,500	1,163,200	1,264,000	100,800	1,534,200	1,754,800	220,600
Hike - Backpacking	752,800	647,900	0	804,000	967,500	163,500	838,600	1,180,700	342,100	906,400	1,638,100	731,700
Nature Study	815,600	701,900	0	990,000	1,048,100	58,100	1,163,200	1,279,000	115,800	1,534,200	1,773,700	239,500
Camping - With Facilities	651,000	716,400	65,400	726,000	1,069,700	343,700	776,000	1,305,300	529,300	901,000	1,807,000	906,000
Four-Wheeling	203,400	205,800	2,400	255,400	307,400	52,000	289,300	375,200	85,900	362,500	521,500	159,000
Power Boating - No Skiing	178,700	187,100	8,400	178,700	279,500	100,800	178,700	341,100	162,400	178,700	474,100	295,400
Power Boating - With Skiing	52,800	55,800	3,000	52,800	83,300	30,500	52,800	101,700	48,900	52,800	141,300	88,500
Trail Bike	84,500	86,100	1,600	106,500	128,600	22,100	120,800	157,000	36,200	151,500	218,400	66,900
Canoe, Sail, or Row Boating	98,800	105,700	6,900	106,000	157,900	51,900	106,000	192,700	86,700	106,000	267,900	161,900
Snow Ski	199,400	171,600	0	199,400	256,400	57,000	199,400	312,900	113,500	419,400	435,500	16,100
Sled - Toboggan	88,400	76,100	0	108,600	113,700	5,100	128,600	138,700	10,100	172,200	193,100	20,900
Cross Country Skiing	71,200	61,300	0	89,200	91,600	2,400	98,200	111,800	13,600	113,700	155,600	41,900
Snowmobiling	74,200	133,300	59,100	174,000	199,000	25,000	209,200	242,900	33,700	284,400	337,000	52,600

1/ Apache, Navajo, and Coconino Counties

TABLE 12A - Existing and Projected Supply, Demand, and Unmet Recreation Demand, Future Without Plan Conditions In Activity Occasions, Little Colorado River Basin

New Mexico Three County Area 1/

Activity	Base Year - 1975			Projected - 1990			Projected - 2000			Projected - 2020		
	Supply	Demand	Unmet Demand	Supply	Demand	Unmet Demand	Supply	Demand	Unmet Demand	Supply	Demand	Unmet Demand
Fishing	278,500	237,770	0	279,800	386,950	107,150	281,100	475,350	194,250	281,100	782,020	500,920
Picnicking	374,000	227,580	0	494,000	384,650	0	554,000	475,600	0	674,000	781,250	107,250
River and Lake Swimming	63,500	60,270	0	63,500	87,970	24,470	63,500	107,760	44,260	63,500	176,720	113,220
Camping - Primitive	124,420	74,110	0	125,020	125,650	630	155,430	155,430	0	203,120	255,560	52,440
Hike - Backpacking	930,560	166,580	0	930,560	275,190	0	930,560	339,560	0	930,560	558,620	0
Nature Study	960,000	307,350	0	960,000	507,450	0	960,000	629,070	0	1,020,300	1,040,390	20,090
Camping - With Facilities	62,480	38,360	0	106,480	62,450	0	128,480	77,240	0	161,480	126,970	0
Four-Wheeling and Trail Bike	360,000	74,540	0	360,000	120,870	0	360,000	148,980	0	360,000	242,500	0
Boating, Canoeing, Sailing	54,810	57,820	3,010	54,810	90,570	35,760	54,810	110,600	55,790	54,810	199,780	144,970
Power Boating - With Skiing	16,330	34,730	18,400	16,330	48,480	32,150	16,330	59,300	42,970	16,330	98,170	81,840
Snow Ski	0	54,580	54,580	0	91,580	91,580	0	113,020	113,020	0	187,740	187,740
Sled, Toboggan, Innertube	37,640	31,550	0	46,740	49,830	3,090	55,140	60,920	5,780	85,140	101,020	15,880
Cross-Country Ski	8,500	7,200	0	10,100	11,120	1,020	11,600	13,650	2,050	17,000	22,710	5,710
Snowmobiling	3,740	3,240	0	4,440	4,730	290	5,240	5,860	620	7,840	9,540	1,700

1/ McKinley, Valencia, and Catron Counties

report was prepared on Rio de Flag in December 1976. At that time, it appeared that an excellent development potential existed for a multi-purpose recreation-fish and wildlife development. However, since 1976 conditions in the planning area have changed and it now appears that the water that was to be used for the fish and wildlife developments will be used for other purposes. Without these developments,the other features of the project would not be as attractive and would not produce the desired benefits. Consequently, this potential project was not considered any further in this study.

The five remaining sites are believed to have considerable development potential. These include: Woodruff Lake, Woodruff Dam (Reservoir), Ganado Lake, Red Lake and McHood Park. All five of these sites have favorable benefit to cost ratios, and are located within the Little Colorado River Plateau Resource Conservation and Development (RC&D) Area. The RC&D Program could provide planning and implementation assistance to each of these areas.

The potential recreation developments were formulated using USDA procedures for Planning Water and Related Land Resources. A recommended alternative for each potential development was formulated after due consideration had been given to both the NED and EQ alternatives.

The recommended alternative for Woodruff Lake is a multi-purpose plan for water-based recreation and fish and wildlife. Specific fish and wildlife elements include constructing some low islands in the shallow areas of the lake along the southern shore, fencing the area, and seeding the islands and shorelines with suitable food and cover plants for waterfowl. The recreation features of the plan call for the construction of nature trails; a 12 unit campground with pad and other associated improvements; a 12 unit picnic area complete with ramadas, grills and other features; a potable water supply; and sanitary facilities. This development is expected to supply a quality recreation experience for appoxorimately 9,000 visitor days annually.

The recommended development for Woodruff Dam (Reservoir) would be to construct a small picnic area, six tables with ramadas and other associated items; a small camping area, six campsites with pads and other associated items; a potable water supply; and sanitary facilities. This development will provide about 4,500 visitor days of recreation annually.

The recommended plan for Ganado Lake includes constructing a multiple-purpose dam across Pueblo Colorado Wash, about 2,000 feet south of an existing dam, associated recreation facilities, and an irrigation outlet structure. The lake would have a recreation pool of 670 surface acres. Total storage capacity of the dam would be 24,000 acre-feet. Planned recreational facilities include a fully developed 100 unit camping area; a 40 unit picnic area; hiking trails; a marina; and associated water supply and sanitary facilities. An estimated 301,000 visitor days annually would be supplied by this facility.

The recommended plan for Red Lake includes improving access to the lake and constructing basic recreation facilities. These facilities include a fully developed 24 unit campground; a fully developed 12 unit picnic area; a water supply; a boat ramp; and sanitary facilities. It is estimated that this development would accommodate about 20,200 additional visitor days annually.

The recommended plan for McHood Park is to construct quality recreation facilities around a new lake formed by a new dam, located downstream of the existing Clear Creek Dam. These facilities include a dining ramada; fully developed camping areas to accommodate 144 travel trailers and 25 tent sites; 40 picnic tables with ramadas and other features; boat ramps and dock; three swimming beaches; a potable water supply; and sanitary facilities. This development is expected to provide a quality recreation experience for about 68,400 visitor days of use each year.

The development of these sites will help to satisfy part of the recreation need within the Basin. Installation cost for the five projects, including operation, maintenance and repair, and project administration, was estimated at $1,027,040.

Fish and Wildlife

Forest lands provide habitat for a wide variety of wildlife species. Forest trees and associated understory shrubs and grasses furnish wildlife with cover and provide food in the form of seeds, acorns, nuts, twigs, bark and foliage. The special habitat needs of endangered, threatened, and unique species of wildlife are considered by all federal and state agencies in their management and project proposals. Among the numerous species utilizing the forest and grassland habitats, at least 21 are classified as being either endangered or unique.

Some wildlife species, such as mule deer, elk, white-tailed deer, antelope, black bear, and turkey are important for hunting. Numerous lesser forest mammals, birds, reptiles, amphibians, insects and other organisms, in addition to being a direct source of aesthetic enjoyment to many people, are important links in natural food chains. They not only perform the vital function of helping maintain stability in natural ecosystems, but are necessary to non-consumptive uses such as bird-watching, natural photography and environmental study.

The intensity of wildlife management and habitat conservation practices is dependent on the objectives of the principal landowners and/or management agencies. (See Land Ownership and Administration Map.) Certain practices relating to livestock grazing are beneficial to some wildlife species; e.g., water developments and rangeland seeding.

The importance of riparian zones is indicated by wildlife use being disproportionately more than in any other type of habitat, heavier use by cattle than in other areas, and recreationists often concentrate their use in such areas.

All riparian zones have these things in common: (1) they create well-defined habitat zones within the much drier surrounding areas; (2) they make up a minor proportion of the overall area; (3) they are generally more productive in terms of biomass (plant and animal) than the remainder of the area; and (4) they are a critical source of diversity within the ecosystem.

Riparian zones occupy relatively small areas and should be considered vulnerable to alteration. Because of the distinct vegetative community and

the structure of riparian zones, they must be considered fragile and sensitive to management activities. Riparian zones are so different from one another that specific animal-to-habitat relationships are difficult to develop for these areas. Forestland managers should consult both fishery and wildlife biologists when management activities are planned within the riparian zone.

There are 70 miles of streams and 6,580 surface acres of ponds, reservoirs and lakes currently suitable for fishing. Both streams and lakes are managed on an annual "put and take" basis for trout. The demand for fishing in the Basin is estimated to increase by about 3 percent annually from 1980 to 2020.

Irrigation impoundments also provide fishing opportunities, but due to seasonal drawdown of water, it is difficult to maintain good fish habitat and fishing conditions. Many of the streams and impoundments on federal lands are being monitored by biologists for water quality and opportunities for fishery improvement work.

Some of the opportunities for improving recreational fishing include:

1. Proper watershed management and proper operation and maintenance of diversion structures to minimize siltation of lakes.

2. Regulation of the use of irrigation water and improvement of irrigation distribution systems to minimize waste of stored water.

3. Construction of additional fishing lakes as long as such lakes incorporate proper design criteria for fish conservation such as adequate depth, protection from siltation, etc.

4. Deepening of shallow lakes by increasing the height of the dam, relocation of the dam, excavation of the bottom, or other feasible means.

5. Eradication of trash fish from all lakes that are suitable for trout management.

6. Improve grazing and timber harvest techniques within streamside zones to maintain desirable vegetation cover for good fish habitat.

Timber

Opportunities exist for forested lands to contribute more fully and effectively to meeting demands for wood products. Many of the forest landowners, both public and private, are managing their forest lands under a planned systematic basis. The growing population and economies of the southwest are generating ever-increasing demands for forest and woodland products.

Steps can be taken immediately to insure that the potential wood productivity of forested lands are more fully developed and the products more completely utilized. Timber stand improvement (TSI) includes a variety of management practices designed to change stand conditions. By removing excess or low value trees, the best trees are left to accumulate growth and value more rapidly. The excess trees could be utilized as fuelwood or converted to chips for further processing.

Cost-sharing programs are available to private landowners through their state forestry organizations to provide tree seedlings for reforestation, windbreaks and Christmas tree plantations. Prompt regeneration of productive forest lands is essential if future demands for wood fiber are to be met.

A critical forest management activity in the Basin involves the prevention and control of wildfire. Wildfires destroy trees, sear merchantable timber and consume soil cover and nutrients, seriously reducing net growth. Cooperative agreements between fire districts or associations and the State Foresters of Arizona and New Mexico have substantially contributed to the success of fire control efforts in the Basin.

Each year, numerous trees are weakened, damaged, or destroyed as a result of insect and disease attack. Protection efforts have been principally directed toward reducing the effects of dwarf mistletoes. Although the dwarf mistletoes are the principal destructive agents present in the Basin, there are many other forest insect species that also attack trees. Some of the more common ones include spruce beetles, Ips beetles, western pine beetles, pine needle miners, and pine tip moths. Preventive measures to keep insect populations and diseases under control are usually more effective, economical and environmentally acceptable than direct measures.

Increases in timber supplies can be realized through more efficient timber harvesting, increased recovery from lumber and wood product processing, better utilization of logging residues and programs which provide technical assistance to landowners and sawmill operators.

Because of the checkerboard pattern on much of the national forest, this has made it difficult to effectively manage these lands. The Forest Service's basic policy has been to exchange or purchase lands that will tend to consolidate or "block-in" national forests. This "blocking-in" helps to improve resource management, alleviate access problems, improve fire management, etc.

Although forest management offers great promise for widespread public benefits, it also presents complex challenges for both private and public land managers in deciding how to make the best use of the land for everyone concerned while maintaining a quality environment for generations to come.